NORTHROP GRUMMAN

Transmittal

Date: December 16, 2020

To: Michael Schulman
Remedial Project Manager, Superfund Division
U.S Environmental Protection Agency Region 9
75 Hawthorne Street, SFD-7-1
San Francisco, CA 94105

From: Shantal Der Boghosian, Environmental Remediation Project Manager
Northrop Grumman Systems Corporation
One Space Park
Mail Stop: NGC CER-XE6D21
Redondo Beach, CA 90278

Subject/Title: **DEVELOPMENT OF THE ENVIRONMENTAL SEQUENCE STRATIGRAPHY (ESS) CONCEPTUAL SITE MODEL (CSM) FOR GROUNDWATER AT THE FORMER TRW MICROWAVE SITE, SUNNYVALE, CALIFORNIA**

CC: Rebecca Mora, AECOM
Holly Holbrook, AECOM

Northrop Grumman System Corporation is submitting the above-referenced

	For your review and comment
X	For your information and file
	For your approval
	For your signature

Total number of copies sent: 1

Remarks: DEVELOPMENT OF THE ENVIRONMENTAL SEQUENCE STRATIGRAPHY (ESS) CONCEPTUAL SITE MODEL (CSM) FOR GROUNDWATER AT THE FORMER TRW MICROWAVE SITE, 825 STEWART DRIVE, SUNNYVALE, CALIFORNIA

If you have any questions or comments regarding the enclosed report, please feel free to call Shantal Der Boghosian at 310-332-7612.

BURNS & McDONNELL

December 5, 2020

Shantal Der Boghosian, Environmental Remediation Project Manager
Northrop Grumman Systems Corporation
One Space Park
Mail Stop: NGC CER-XE6D21
Redondo Beach, CA 90278

Re: **Technical Memorandum - Development of the Environmental Sequence Stratigraphy (ESS) Conceptual Site Model (CSM) for Groundwater at the Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California**

Dear Ms. Der Boghosian:

Burns & McDonnell, Inc. is pleased to submit the attached Technical Memorandum to Northrop Grumman Systems Corp. If you have any questions, please contact me at rcramer@burnsmcd.com.

Sincerely,
BURNS & MCDONNELL, INC.

Rick Cramer, PG No. 4337
Project Manager

Mike Shultz, PhD
Project Stratigrapher

BURNS McDONNELL

TECHNICAL MEMORANDUM

DATE: December 5, 2020

DEVELOPMENT OF THE ENVIRONMENTAL SEQUENCE STRATIGRAPHY (ESS) CONCEPTUAL SITE MODEL (CSM) FOR GROUNDWATER AT THE FORMER TRW MICROWAVE SITE, 825 STEWART DRIVE, SUNNYVALE, CALIFORNIA

TABLE OF CONTENTS

Development of the Environmental Sequence Stratigraphy (ESS) Conceptual Site Model (CSM) for Groundwater at the Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California

1.0 EXECUTIVE SUMMARY

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) has prepared this Technical Memorandum on behalf of Northrop Grumman Systems Corporation (Northrop Grumman) to document the development and evolution of the Environmental Sequence Stratigraphy (ESS) conceptual site model (CSM) for groundwater at the Former TRW Microwave Site.

The TRW Microwave site (TRW Site) at 825 Stewart Drive in Sunnyvale, California is a former industrial manufacturing and semiconductor processing facility and is one of multiple sources of contamination that contributed to the formation of the mile long "Triple Site" groundwater plume (Figure 1). The primary contaminants in this plume are chlorinated volatile organic compounds (cVOCs), including trichloroethene (TCE) and its daughter products (cis-1,2-dichloroethene [cDCE] and vinyl chloride [VC]). The TRW Site, together with three other operable units (OUs), was included in a 1991 Record of Decision for the Triple Site. The four OUs for the Triple Site are as follows: (1) The Advanced Micro Devices (AMD) 901/902 Site OU; (2) The Philips Site OU; (3) The TRW Site OU; and (4) The Companies Offsite Operable Unit (OOU), a commingled plume of contaminants which originated from the other three operable units (and has contributions from other sites in the area). These OUs are shown on Figure 1.

Site characterization activities at the TRW Site commenced in the mid-1980's, and extensive remedial actions were taken in the following decades, including source removal, in-situ source treatment, and groundwater extraction and treatment. Despite these actions, contaminant concentrations in groundwater to the north of the site, in the general downgradient direction with respect to groundwater flow, remained significantly above maximum contaminant levels (MCLs). In 2014, the United States Environmental Protection Agency (USEPA) Five-Year Review (USEPA, 2014) noted the increasing concentrations of contaminants above MCLs in a groundwater monitoring well (T-9B, Figure 4) that was along the presumed downgradient boundary of the TRW Site. USEPA questioned the effectiveness of the remediation actions taken by Northrop Grumman and identified remedy performance as an issue, raising the prospect of additional investigation for contamination and remedial actions in the former source area.

In response to the findings put forth in the 2014 Five-Year Review, Northrop Grumman initiated an ESS analysis at the TRW Site to assess stratigraphic control on the groundwater dynamics and contaminant occurrence underlying the TRW Site. ESS refers to the application of the petroleum industry best practices for subsurface interpretation known as sequence stratigraphy and facies models to aquifer characterization and groundwater remediation (Shultz et al., 2017). The analysis used existing borehole lithologic data to elucidate grain size trends within the aquifer and prepare preliminary stratigraphic cross sections and maps of the geologic features controlling groundwater flow and contaminant migration in the subsurface. The preliminary ESS interpretation showed that T-9B was screened across two distinct buried fluvial (river channel) deposits, which are gravel bearing and laterally discontinuous channel form (see Figure 6). These deposits represent permeable pathways for groundwater flow and contaminant transport, otherwise known as “hydrostratigraphic units” or “HSUs”. The mapping showed that the two distinct channels intercepted different contaminant sources, one of which extends to TRW-related contaminant source zone and the other traceable to off-site sources entering the TRW site from up-gradient (see Figure 11). Contaminant fingerprinting validated that the channel deposits represent distinct HSUs.

The preliminary 2014 mapping was verified and augmented in subsequent field investigations utilizing high-resolution site characterization data (membrane interface probe [MIP]/ hydraulic profiling tool [HPT]), and depth-discrete groundwater samples were obtained via HydroPunch™ methods to verify the initial ESS interpretation and provide additional infill data to identify other potential pathways of contaminant transport from off-site. The resultant CSM for the TRW Site identifies three HSUs within the “B” depth zone, which represent distinct groundwater flow pathways with unique contaminant concentrations and potentiometric surfaces. All three HSUs are monitored upgradient and downgradient of the former TRW source area. Thus, the ESS CSM provides a comprehensive understanding of groundwater flow and contaminant migration on- and off-site.

2.0 REGIONAL SETTING AND STRATIGRAPHY

The TRW Site is located within the Santa Clara Valley at the south end of the San Francisco Bay (Figure 2). The Santa Clara Valley is located within the California Coast Ranges physiographic province and is bounded on the west by the Santa Cruz Mountains and on the East by the Diablo Range. The valley is floored by approximately 1,300 feet of Quaternary strata overlying basement rocks, representing the fill of the Santa Clara Basin (Wentworth et al., 2015). The basin formed as a result of right-lateral motion along the strike-slip San Andreas and Hayward Faults.

The Quaternary basin fill consists of eight distinct fining-upward sequences overlying several hundred feet of fine-grained material (Wentworth et al., 2015, Figure 3). The fining-upward sequences are laterally correlative throughout most of the basin, and consist of basal gravels overlain by interbedded sand, silt, clay, and minor gravel beds, with clay-rich upper sections. The basal gravel deposits overlie unconformities formed during low stands of sea-level (glacial periods). The groundwater aquifers impacted by contamination at the Triple Site correspond to Sequences 1 and 2 of Wentworth et al., 2015.

3.0 ENVIRONMENTAL SEQUENCE STRATIGRAPHY (ESS): BACKGROUND OF THE TECHNOLOGY

The science of sequence stratigraphy was initially developed in the petroleum industry based on basin-scale reflection seismic studies, and identification of termination of seismic reflectors on continental margins as related to global sea level changes for petroleum exploration purposes (e.g., Mitchum et al., 1977). However, during the decades since this seminal work the concepts have been applied at increasingly smaller scales on well logs and cores, outcrops, and petroleum reservoirs (Van Wagoner et al., 1990). Sequence stratigraphy and facies models represent current best practice for predicting and delineating the geometry and continuity of subsurface strata.

"Environmental Sequence Stratigraphy" refers to the application of both the concepts of sequence stratigraphy and facies models (discussed below) to groundwater investigations and remediation programs. ESS analyses have been applied to groundwater remediation and water resource studies since the 1990s (Ehman and Cramer, 1996; Ehman and Cramer, 1997), and the importance of advanced stratigraphic methods for understanding aquifer heterogeneity has been emphasized by numerous authors (*e.g.,* Koltermann and Gorelick, 1996; Weissmann and Fogg, 1999; Biteman, et al., 2004; Ponti, et al., 2007; Payne, et. al., 2008; Scharling, P. B., et. al., 2009). Recently, the application of ESS to groundwater remediation has been increasingly widespread and is recognized as a best practice for development of CSMs for groundwater remediation (Shultz et al., 2017). The increase in application of ESS is due in large part to the recognition within the industry and regulatory community that groundwater remediation projects have not achieved cleanup goals in expected timeframes, due in large part to the challenges imposed by heterogeneous geologic conditions (National Research Council, 2013).

Methodology Overview

ESS is a geology-focused analysis of subsurface data that applies the understanding of depositional environments and their relationship to the occurrence of permeable deposits (sand and/or sand and gravel) and low permeability deposits (silt and/or clay) in order to map out key pathways and obstructions within a site's subsurface stratigraphic framework. A site's stratigraphic framework defines the permeability architecture which is the primary control on subsurface fluid flow. The result of the ESS analysis is a three-dimensional understanding of the geologic framework. Once the static geologic framework is defined, the dynamic subsurface data sets (e.g., hydrogeology and chemistry) can be evaluated within this framework. Typically, the site stratigraphy is used to define specific hydrostratigraphic units (HSUs) that inform the mapping of potentiometric surfaces and interpretation of contaminant chemistry data.

4.0 EVOLUTION OF THE ESS CSM FOR THE TRW MICROWAVE SITE

This chapter presents the evolution of the development of the ESS-based CSM for the TRW Site. Included is a summary of the agency-driven activity related to the CSM development.

Initial ESS Evaluation (2014-2015)

The initial ESS evaluation at the TRW Site was an analysis of existing site data in response to the 2014 FYR. At that point in time USEPA observed groundwater potentiometric surface maps as presented in OOU monitoring reports (Figure 4). Based on the inferred groundwater gradients, the FYR concluded that the contamination detected in well T-9B was indicative of residual TRW Site source mass and the on-site remedies were not effectively reducing groundwater COCs or containing off-site migration, as summarized below.

- Issue Category: Remedy Performance
- Issue: Increasing COC concentrations in downgradient wells indicates that the remedy is not containing off site migration.
- Recommendation: Investigate and implement optimization options for the in-situ bioremediation source area treatment to increase downgradient capture zone for contaminated groundwater.

Historically, practitioners at the TRW Site had subdivided the saturated zone into depth-defined zones, as is common practice for contaminated groundwater sites. The depth-based zonation included the “A Zone” (0’-20’ below ground surface (bgs)), the “B1 Zone” (20’-40’ bgs), “B2 Zone” (40’-60’ bgs), “B3 Zone” (60’-80’ bgs). The objective of the initial ESS analysis at the TRW Site was to critically review existing site data in the context of the depositional environment and determine if sufficient subsurface data existed to map contaminant pathways (channel deposits) within the B1 Zone aquifer units impacted at the TRW Site, and asses the contaminant concentrations at the downgradient fence line in light of the ESS analysis.

The initial ESS analysis at the TRW Site utilized historic boring log descriptions to refine the CSM for groundwater with a focus on the B1 Zone. Existing boring log data for the TRW Site and surrounding sites, to the extent logs were publicly available, were reviewed in detail and grain size data were then plotted with depth to produce Graphic Grain Size Logs ((GSLs), Figure 5). These GSLs provide graphic representations of grain size trends vertically within any individual boring log, and laterally between boring locations. As seen in Figure 5, permeable units at the TRW Site consist primarily of fining-upward sequences with gravelly zones at the base overlain by progressively finer sand, silt, and clay deposits. This grain size signature is typical of fluvial (river channel) deposits, and more specifically “anastomosing” or “meandering” type deposits. A depositional model or “facies model” for an anastomosing river is presented as Figure 6. Given the prevalence of fining-upward sequences recorded in the boring log descriptions, the overall plan-view morphology of the channel deposits can be predicted based on the facies model for anastomosing river deposits (Figure 7). The deposits of such river systems are typically ribbon-like, and slightly sinuous in map view. Also, the pre-industrial development drainage courses of modern streams in the valley were reviewed on historic topographic maps, and these were considered in the process of interpretation of the aquifers at the TRW Site as fluvial channel deposits (Figure 8).

The database for the initial ESS analysis consisted of boring logs, well construction data, and analytical data from groundwater sampling events (Figure 9). GSLs were prepared for all the boring logs to highlight vertical grain size trends and for posting on geologic sections. In order to assess the issues raised in the 2014 FYR, a series of geologic cross sections were generated. Cross section A-A' (Figure 10) was prepared extending east to west across the TRW Site and extending west to include off-site wells (Figure 10 presents an un-interpreted and an interpreted cross section). The interpretation of channel deposits was guided by the vertical grainsize patterns elucidated by the GSLs, extensive experience in fluvial facies models, and stratigraphic "rules of thumb" including the following:

- Channel deposits tend to have erosive bases and flat tops, and clays make superior correlation markers representing floodplain deposits and/or ancient soil horizons (paleosols)
- Gravel-bearing sands define channel bases (lags), and grain size fines upward
- Channel margins tend to be sharp and erosive, and result in segregation of channel-fill sands and gravels from floodplain clays

Coarse-grained channel deposits in the saturated zone represent potential pathways for groundwater flow and contaminant flux which have limited hydraulic connection to other parts of the aquifer. Such hydrogeologic features are referred to as "hydrostratigraphic units", or "HSUs". HSUs may have unique contaminant profiles and water levels due to their isolated occurrence.

Inspection of cross section A-A' (Figure 10) reveals that onsite groundwater monitoring wells designated as Zone B1 wells (T8B, T-2B, and T-17B) are screened in a shallower, isolated channel deposit relative to the offsite wells S005B1, S149B1, S101B1, and S048B1, which are screened across slightly deeper channel sands. These two channel deposits were suspected to represent distinct HSUs, and as such were designated HSU-1 and HSU-2, respectively (Figure 11). Note that all wells have historically been grouped in the "B1 Zone", despite being screened in distinct channel deposits.

After identification of the HSU-1 and HSU-2 channel deposits in geologic cross sections, these units were carefully mapped across the study area. Maps of the distribution of geologic materials in the subsurface are referred to as "facies maps". Preliminary facies maps defined the two HSUs (Figure 11). At this point in time, facies maps of the B1 interval were prepared at five-foot intervals. Detailed maps from 2015 are presented in Figure 12. While the B1 zone has been the focus of the ESS analysis, facies maps of the A zone were also prepared (Figure 13).

To validate the potential for these two channels to represent distinct HSUs and contaminant transport pathways, groundwater contaminant data were incorporated to provide an independent line of evidence (Figure 11). The primary contaminants at both the TRW Site and the surrounding Philips and AMD sites are cVOCs, primarily TCE and its daughter products; however, the Philips site has an additional compound, Freon 113 that is considered to be exclusively from the Philips location. At the time of the initial evaluation, both the TRW Site and upgradient AMD site had implemented enhanced reductive dechlorination (ERD) bioremediation programs, leading to the generation of daughter products cDCE, vinyl chloride, and ethene. This was not true for the Philips site where no bioremediation was implemented at this contaminant source area.

The concentration data showed that vinyl chloride was only detected in groundwater samples obtained from wells screened across HSU-1 and were devoid of Freon-113. Yet Freon-113 was only detected in groundwater samples from wells screened across HSU-2 and were devoid of vinyl chloride. Samples obtained from Well T-9B, however, which was screened across both HSU-1 and HSU-2, contained both Freon-113 and vinyl chloride. As vinyl chloride was produced as a daughter product from remediation activities at the TRW-Site, and Freon-113 was used only in off-site processes, these contaminants provided a "tracer" from the related source areas and provides an independent line of evidence that confirms that the two channel deposits, HSU-1 and HSU-2, are hydraulically isolated pathways for contaminant transport.

The methodology and results of this initial ESS analysis were presented to USEPA in the *Technical Memorandum in Response to the 2014 Five-Year Report* (AECOM, 2015) and during a meeting on December 10, 2015. Additional clarifications were presented in the Addendum to the *Technical Memorandum in Response to the 2014 Five-Year Review Report* (AECOM, 2016a). The ESS pathways were then incorporated in the *Conceptual Site Model, submitted to USEPA* in April 2016 (AECOM, 2016b). USEPA concurred with the analysis and the HSU approach, and also concurred with the ESS assertion that groundwater flow pathways based on water levels alone were likely inaccurate. USEPA requested Northrop Grumman execute a field program to determine a "background" level of contamination being carried on-site from upgradient sources via the permeable pathways (HSUs). This would serve in lieu of being held to the MCLs for contaminants of concern (CoC) at the "downgradient" site boundary. USEPA also concurred that additional source area remediation was not necessary given the contaminant transport from the Philips property to the TRW Site monitoring wells.

July 2016 Geoprobe MiHPT / HydroPunch™ Field Program

The July 2016 Membrane Interface Probe (MIP) / Hydraulic Profiling Tool (MiHPT) / HydroPunch™ field program was part of proposed work in the *Background Water Quality Evaluation Work Plan* (AECOM, 2016c). The purpose of the work was to improve interpretation of HSUs as potential contaminant migration pathways and to assess appropriate cleanup goals for the site given contaminant transport onto the TRW Site from upgradient contaminant source areas.

The investigation was performed using a combined MiHPT followed by HydroPunch™ depth-discrete groundwater sampling at eight locations across the Site (Figure 14). MIP data were collected to qualitatively identify dissolved-phase contamination in groundwater, and HPT data provide information regarding relative permeability of the different strata. Details regarding the MiHPT program, including details regarding the specifications of the profiling tools and results of the field program are provided in the 2016 *Background Water Quality Evaluation Report* (AECOM, 2016d).

MiHPT data collection, in large part, confirmed the CSM developed during the initial ESS analysis, adding confidence to the interpretation (Figure 15). The logs collected provided clear evidence that permeable channel deposits are the contaminant transport pathways at the TRW Site, and HydroPunch™ groundwater samples confirmed that HSU-2 is a pathway for contamination coming onto the site. Facies maps were updated based on the additional data collected and presented in the May 2018 *Well Installation Work Plan* (AECOM, 2017). In addition, a third HSU channel (HSU-3) was identified (Figure 16).

The following conclusions and recommendations were presented in the *Background Water Quality Evaluation Report* (AECOM, 2016d):

> The MiHPT survey confirmed the results of the previous ESS evaluation and resulting CSM. This MiHPT survey identified three locations where additional Zone B1 monitoring wells are needed to evaluate and monitor Site-derived COCs concentrations at the northern Site boundary, as well as concentrations coming onsite from offsite Philips sources along the southern and western Site boundaries:
>
> 1. At the northern Site boundary, a new well is proposed near the location of borehole BH8. The well will be screened across HSU1 and will be representative of downgradient contaminant concentrations from the former Site source area.
>
> 2. At the western Site boundary, a new monitoring well is proposed near the location of borehole BH6 and will be screened across HSU3. This location is cross gradient of the former Site source area and as such represents concentrations coming onto the Site from offsite Philips sources to the west.
>
> 3. At the southern Site boundary, a new well is proposed near the location of borehole BH2. The well will be screened across HSU3 and will monitor concentrations coming onto the Site from offsite sources to the south, as identified in BH2.

2017 and 2018 Field Programs

A *Well Installation Work Plan* (WIP)(AECOM, 2017) was submitted to USEPA to outline the field work to be performed to address the data gaps identified in the background study. On May 15, 2017 Northrop Grumman and its consultants convened a meeting with USEPA to discuss the WIP and gain concurrence prior to its execution. As a result of comments received from USEPA at that meeting, a revised version of the work plan was submitted in June 2017. In August 2017, field work was performed at the Site to address the identified data gaps and five new monitoring wells were installed (Figure 17), as documented in the *Well Installation Report* (AECOM, 2018a). T-20B and T-21B were installed in HSU-3 to monitor concentrations coming on-site from the south and concentrations leaving the Site along the western boundary.

Monitoring wells T-22B, T-23B, and T-24B were installed in the vicinity of T-9B to monitor HSU-1 and HSU-2 more precisely. The screened intervals were based on BH-9 lithology (continuous core direct push borehole) and associated HydroPunch™ sample results which were consistent with the ESS CSM. The wells were installed close to, but not in the exact location of the borehole, BH-9. Analytical results from groundwater sampled from the new monitoring wells in 2017 and 2018 sampling rounds were not consistent with the HydroPunch™ sample results obtained immediately prior to well installation. Variability in concentrations of contaminants in HydroPunch™ samples and monitoring wells constructed in the same location and at the same elevation is reflective of subtle differences in groundwater flow paths, and likely related to matrix diffusion effects in the vicinity of T-9B.

T-9B had been an extraction well in operation for many years, extracting groundwater with high concentrations of contaminants. The well was screened across two distinct HSUs, and therefore pulled impacted groundwater across silt and clay deposits, thereby charging the silt and clays nearby the well with matrix contamination. Therefore, due to subtle variability in groundwater flow rates and directions in the vicinity of the former extraction well, and subtle permeability variation over extremely small distances laterally and vertically, variability in concentrations is not unexpected in this environment. Evidence of matrix-bound contamination in this area at the depths corresponding to HSU-1 and HSU-2 is apparent in the MiHPT data from this area (Figure 18). In this log both the XSD and ECD logs (which respond to CVOCs) show elevated response not only in the coarse-grained HSU-1 at 29 feet, but also in the fine-grained silt and clay from 24 feet to 35 feet below ground surface (bgs), due to contamination in the matrix material. Temporal variations in concentrations in the former groundwater extraction area should be expected to occur in future sampling events, and should not be considered indicative of active transport of contaminants from the former TRW source area to downgradient monitoring wells.

Based on the results of the investigation and request for clarification from USEPA, additional field work was conducted to enhance the detailed hydrostratigraphy in the vicinity of T-9B, as documented in the *Well Installation Work Plan Letter Addendum* (AECOM, 2018b). In December 2018, another field mobilization deployed a Direct Push Technology (DPT) rig to collect continuous core (BH-10, BH-11, BH-12) and HydroPunch™ samples to determine well screen depths. The objective was to replace the T-9B well, which was screened across both HSU-1 and HSU-2, with short screened wells which would provide representative monitoring of the individual channel deposits. To minimize the differences observed between the borehole and well installations during the previous field effort, the BH-11 location was over drilled and a dual-nested well T-25Bs (screened 25.5 feet to 27.5 feet bgs) and T-25 Bd (screened 33 feet to 36 feet) was installed to monitor HSU-1 and HSU-2 at the downgradient property boundary. The results of this field program were presented in the March 2019 *Well Installation Report Addendum* (AECOM, 2019).

March 29, 2019 EPA Approval of the *Well Installation Report Addendum*.

In March 2019, Northrop Grumman submitted a Well Installation Report Addendum to USEPA to report the results of the field program. The following are the USEPA comments.

- Data (stratigraphic, hydrogeologic, and chemical) collected during the investigation is robust and supports the existence of three distinct HSUs acting as preferred pathways for contaminant migration in the northern portion of the Site. In particular, the Report provides a strong justification for the identification of HSU-1 in the northern portion of the Site.
- EPA approves the Report's recommendation to no longer use well T-9B as a monitoring well and have it properly destroyed.

September 18, 2019 EPA Five Year Review Report (titled *Fifth Five-Year Review Report for Advanced Miro Devices 901/902 and TRW Microwave Superfund Sites, Includes the Companies' Offsite Operable Unit, Santa Clara County, CA*). The results of the 2019 Five-Year Review (FYR) are supportive of the ESS Site strategy as the report points out the following:

- Extensive ESS work done at the TRW Site was beneficial to the CSM and understanding of contaminant migration.
- Included several cross sections and maps generated during the course of the ESS work.
- Supported the HSU approach for the Triple Site as a whole due to the channelized groundwater flow.

Specifically, the 2019 FYR indicated that the issue of increasing chemical concentrations in downgradient wells had been resolved through the detailed ESS HSU mapping, and that the installation of five additional monitoring wells in 2017 (T20B through T24B) had isolated the primary HSUs in the B1 Zone. The recognition of T-9C as a B3 well addressed the issue of additional B3 characterization recommended in the previous FYR. The only remaining issue related to groundwater remediation identified in the 2019 FYR was the need for a revised decision document stating the remedy selected for the site (pump and treat) was no longer in operation (ROD amendment through a FFS).

5.0 2019 CSM UPDATE AND CURRENT STATUS OF HYDROSTRATIGRAPHIC UNIT IDENTIFICATION

In 2019, considering the significant additional data collected since 2016, Northrop Grumman initiated a TRW site-wide ESS CSM update. The update included incorporating all new data collected and creation of a RockWare project database to facilitate three-dimensional analysis for updating facies maps and HSU interpretation. HSU tops and bases were picked in all boring logs and MiHPT logs to generate the most robust dataset possible to improve precision of the HSUs and facies maps for the site. Facies maps were updated for Zones A and B1. With the 3-dimensional data analysis capabilities, the orientation of HSU-3 was updated, and minor refinements were made to other HSU maps. Based on the 2019 CSM update, the current status of the ESS CSM was presented to USEPA on July 9, 2020. The following presents a synopsis of the current CSM for groundwater.

A Zone (40 feet to 15 feet mean sea level [msl])

With the benefit of the high-resolution MiHPT data, a shallower isolated HSU (HSU-3) was identified in the southwestern portion of the Site. The HSU-3 occurs from approximately 15 feet to 20 feet msl, in the zone traditionally identified as the A Zone. Therefore, for the TRW Site, the A Zone is now considered to occupy the elevation interval from the ground surface (approximately 40 feet msl) to 15 feet msl.

In comparison to the deeper B Zones, the A Zone sand channel facies is more widespread across the site, and thus the A Zone is relatively well-connected hydraulically, and appears to behave as a single hydrostratigraphic unit. Several swaths of fine-grained channel margin facies are interpreted oriented north-northeast along the western site boundary, and along the eastern site boundary. Figure 19 shows the facies corresponding to the A Zone with the thickness of channel facies posted at each borehole location. On-site migration of contamination within the A Zone channel deposits is apparent, and concentrations of contaminants in A Zone monitoring wells decreases from upgradient to downgradient across the TRW Site (Figure 20). The fine-grained facies swaths oriented along the western site boundary control contaminant migration as evidenced by Freon-113 concentration distribution in this area (Figure 13).

B1 Zone (15 feet to 0 feet msl)

The B1 Zone consists of three distinct HSUs within the TRW Site, HSU-1, HSU-2, and HSU-3. HSU-3 is the shallowest, as it was first identified after HSU-1 and HSU-2 were defined. As a result, the HSUs at the site, from shallowest to deepest are as follows:

HSU-3 (20 feet to 15 feet msl)
HSU-1 (10 feet to 15 feet msl)
HSU-2 (0 feet to 10 feet msl)

Facies maps showing HSU-3, 1, and 2 with control points and thickness data are presented in Figures 21, 22, and 23, respectively. Index maps for geologic cross sections A, B, and C are presented in Figure 24, a legend to the geologic cross sections is presented in Figure 25, and geologic cross sections A, B, and C, illustrating the HSUs are presented in Figures 26, 27, and 28, respectively.

HSU-3

HSU-3 is approximately two feet thick and oriented northwest-southeast across the southwest corner of the TRW Site. Figure 21 shows the facies corresponding to HSU-3 with borehole locations and thickness of permeable channel facies (as stored in the database) posted on the map. HSU-3 was identified during MiHPT data collection in BH-6 based on HPT response indicating permeable strata and XSD response indicating VOCs in groundwater (Figure 26). HydroPunch™ groundwater samples collected from HSU-3 contained significant concentration of TCE, cis-1,2-DCE, and Freon-113, and lacked VC, consistent with off-site sources. T-20B was installed and screened within HSU-3 near BH-2 to monitor HSU-3 (Figure 21). Groundwater samples obtained from groundwater monitoring wells screened within the HSUs confirm the HydroPunch™ results.

HSU-1

HSU-1 varies in thickness across the Site from about one to three feet where present (Figure 22), and the top of the sand occurs at approximately 15 feet msl at the Site. Figure 22 shows the facies corresponding to HSU-1 with borehole locations and thickness of permeable channel facies as picked in the database posted on the map. The eastern arm of HSU-1 is present in the former TRW source area and extends to the north (Figures 22, 27). Boring log data from T-8D suggest that the A Zone channels scour down and contact HSU-1 in the source area, providing a potential pathway from the shallower A Zone to HSU-1 in the former TRW source area (Figure 27). Additionally, HSU-3 may be in partial communication with HSU-1 (Figure 27), and therefore HSU-3 has the potential to be contributing contaminated groundwater to HSU-1. HSU-1 also has a western arm that parallels the western site boundary. Contaminated groundwater originating from upgradient (Philips) likely travels through this western arm and contributes to HSU-1 contamination in the downgradient Site boundary on the northern edge of the Site. In wells on the southern end of the Site, HSU-1 sand facies are not recorded in boring logs, indicating that the sand pinches out or becomes oriented east to west trending offsite to the east (Figure 22),

HSU-2

Figure 23 shows the facies corresponding to HSU-2 with borehole locations and thickness of permeable channel facies posted on the map. HSU-2 is considerably more widespread across the Site than HSU-3 or HSU-1. A swath of fine-grained material occupies the central portion of the Site at the elevation of HSU-2. No HSU-2 permeable material is present in the former TRW Site source area (Figures 23, 27), further supporting the fact that contaminated groundwater contained within HSU-2 results from onsite migration from upgradient Philips sources. AMD sources may also contribute from farther to the south beyond the Philips panhandle (Figure 1). Historically, groundwater samples obtained from wells which are screened within HSU-2 typically contain Freon-113 and lack VC, providing an independent line of evidence to show that HSU-2 is a transport pathway for contaminated groundwater from the Philips offsite source to flow onto the Site.

6.0 CONCLUDING SUMMARY

The "Triple Site" plume in the Santa Clara Valley represents a classic example of a "complex contaminated groundwater site" (sensu NRC, 2013). Despite more than three decades of intense characterization and remediation efforts, including nearly four decades of groundwater pump and treat system operation from multiple locations across the plume since 1982, significant uncertainties remain regarding subsurface fluid flow, plume containment, and restoration timeframes. Remedy performance has lagged far behind expectations (USEPA, 2019 FYR). This is due to the highly heterogeneous geologic conditions in the impacted aquifer, which is composed of fluvial channel deposits. The Triple Site Plume is a commingled plume, and multiple source areas have been identified. The former TRW Site is one such former source area. ESS methods have been applied to the TRW Site in Sunnyvale California to generate a detailed CSM for groundwater flow and contaminant transport. The principal groundwater flow zones correspond to buried channel deposits that are laterally variable in thickness and may be less than a foot thick in some areas and pinch out completely in others. These buried channel deposits comprise individual hydrostratigraphic units that have limited hydraulic connection with other parts of the aquifer.

The ESS approach has been applied at the former TRW Site during the past five years to develop the CSM for groundwater. The ESS CSM identified three HSUs in Zone B1 in addition to the shallow A Zone. Two of the identified HSUs (HSU-2 and HSU-3) bring contaminated groundwater onto the former TRW Site from upgradient source areas, and the upgradient extent of HSU-1 is uncertain and may pinch out on-site. Facies maps at different stratigraphic intervals elucidate the HSU pathways on-site and groundwater chemistry fingerprints support the interpretations. Groundwater flow and contaminant transport in such heterogeneous settings cannot be predicted based on water level data alone. Well screens that intersect different HSUs and facies patterns must be considered when interpreting groundwater flow directions and contaminant transport vectors.

The current ESS CSM developed for the former TRW Site represents a step-change for the conceptual understanding of the Triple Site and other Santa Clara Valley megaplumes (e.g., the Middlefield-Ellis-Whisman plume). An approach to plume control, management, and remediation that incorporates the concepts of HSUs instead of depth-based aquifer designations is required to restore these sites to a path to closure in reasonable timeframes. It all starts with a firm understanding of the geologic framework.

Proactive ESS CSM development on the part of Northrop Grumman has been embraced by the USEPA. The ESS CSM has conclusively shown that contaminants are migrating onsite from upgradient sources, and therefore maximum contaminant limits (MCLs) for groundwater are not appropriate cleanup goals for the Site. The ESS CSM provides a geologically defensible framework for decision making and site management strategy development at the Site.

8.0 REFERENCES

AECOM, 2015. Technical Memorandum in Response to the 2014 Five-Year Review Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. March 31.

AECOM, 2016a. Addendum to the Technical Memorandum in Response to the 2014 Five-Year Review Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. January 25.

AECOM, 2016b. Conceptual Site Model, Former TRW Microwave Site Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. April 19.

AECOM, 2016c. Background Water Quality Evaluation Work Plan, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. May 4.

AECOM, 2016d. Background Water Quality Evaluation Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. November 15.

AECOM, 2017. Well Installation Work Plan, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. April 13, Revised June 2017.

AECOM, 2018a. Well Installation Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. May 3.

AECOM, 2018b. Well Installation Work Plan Letter Addendum, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California, November 21.

AECOM, 2019. Well Installation Report Addendum, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California, March 12.

Ehman, K.D. and R.S. Cramer, 1996. Assessment of potential groundwater contaminant migration pathways using sequence stratigraphy, Proceedings of the 1996 Petroleum Hydrocarbons and Organic Chemicals in Ground Water, November 13 - 15, 1996.

Ehman, K. D. and R.S. Cramer, R. S., 1997. Application of Sequence Stratigraphy to Evaluate Groundwater Resources: in Kendall, D. R., editor, Proceedings of the American Association of Water Resources Symposium, Conjunctive Use of Water Resources: Aquifer Storage and Recovery, American Water Resources Association, Herndon, Virginia, TPS-97-2, p. 221-230.

Koltermann, C.E. and S.M. Gorelick, 1996. Heterogeneity in sedimentary deposits: A review of structure-imitating, process-imitating, and descriptive approaches. Water Resources Research, Vol. 32, No.9, p. 2617-2658.

National Research Council. 2013. Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites. Washington, DC: The National Academies Press. https://doi.org/10.17226/14668.

Payne, F.C., J.A. Quinnan, and S.T. Potter, 2008. Remediation Hydraulics, CRC Press, 432 p.

Ponti, D. J., K. D. Ehman, B. D. Edwards, J. C. Tinsley, T. Hildenbrand, J. W. Hillhouse, R. T. Hanson, K. McDougall, C. L. Powell, E. Wan, M. Land, S. Mahan and A. M. Sarna-Wojcicki (2007). "A 3-Dimensional Model of Water-Bearing Sequences in the Dominguez Gap Region, Long Beach, California." Open-File Report -U.S.Geological Survey(Reston, VA).

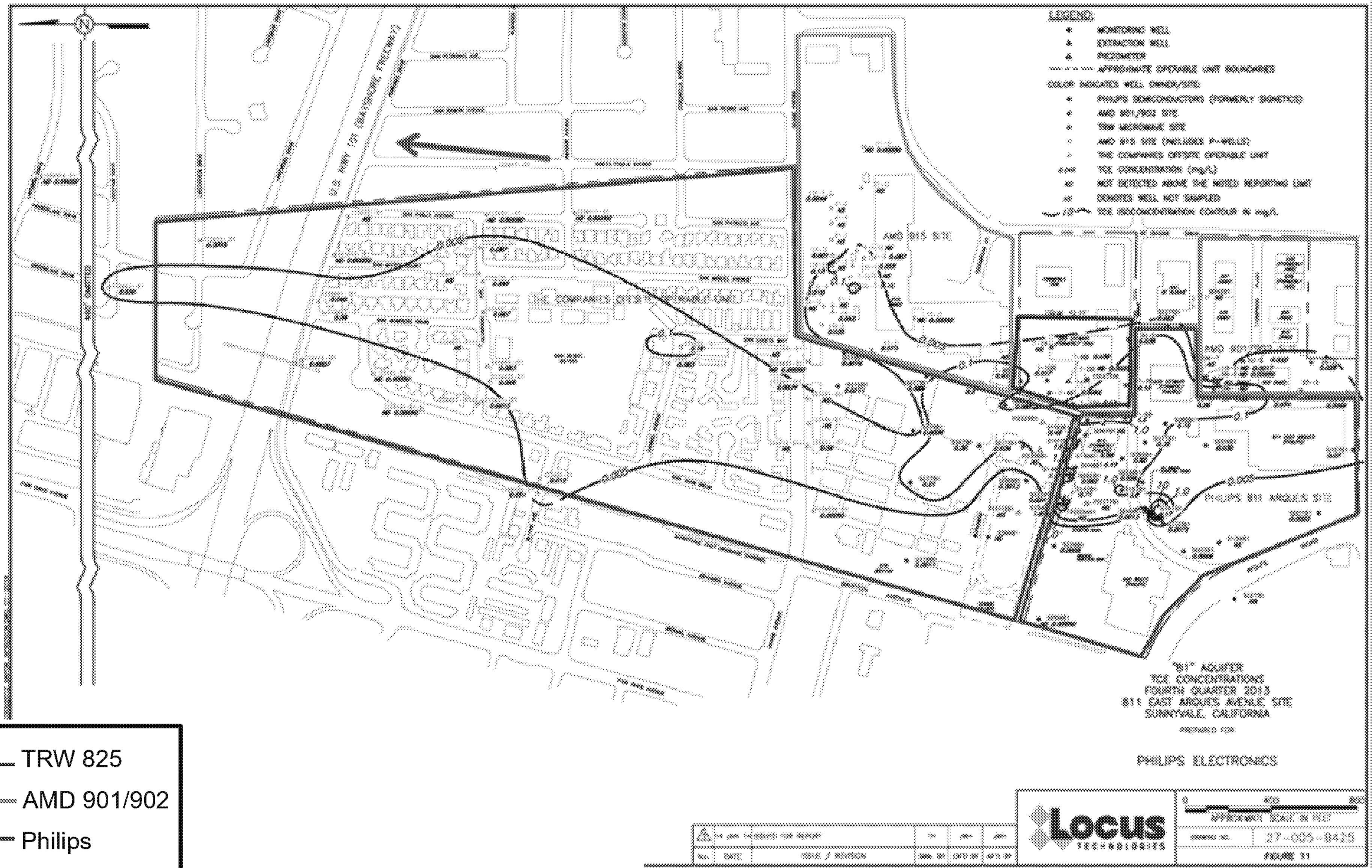
Scharling, P. B., E. S. Rasmussen, T. O. Sonnenborg, P. Engesgaard and K. Hinsby (2009). "Three-dimensional regional-scale hydrostratigraphic modeling based on sequence stratigraphic methods: a case study of the Miocene succession in Denmark." Hydrogeology journal 17(8): 1913-1933.

Shultz, M., R. Cramer, C. Plank, H. Levine, AND K. Ehman. Best Practices for Environmental Site Management: A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-17/293, 2017.

Wentworth C.M. Jachens R.C. Williams R.A. Tinsley J.C. Hanson R.T., 2015, Physical subdivision and description of the water-bearing sediments of the Santa Clara Valley, California: U.S. Geological Survey Scientific Investigations Report 2015–5017 , 73 p., 2 plates, https://doi.org/10.3133/sir20155017.

https://pubs.usgs.gov/of/2005/1169/chapters/of2005-1169_part3_01_Tinsley_Boore.pdf

FIGURES



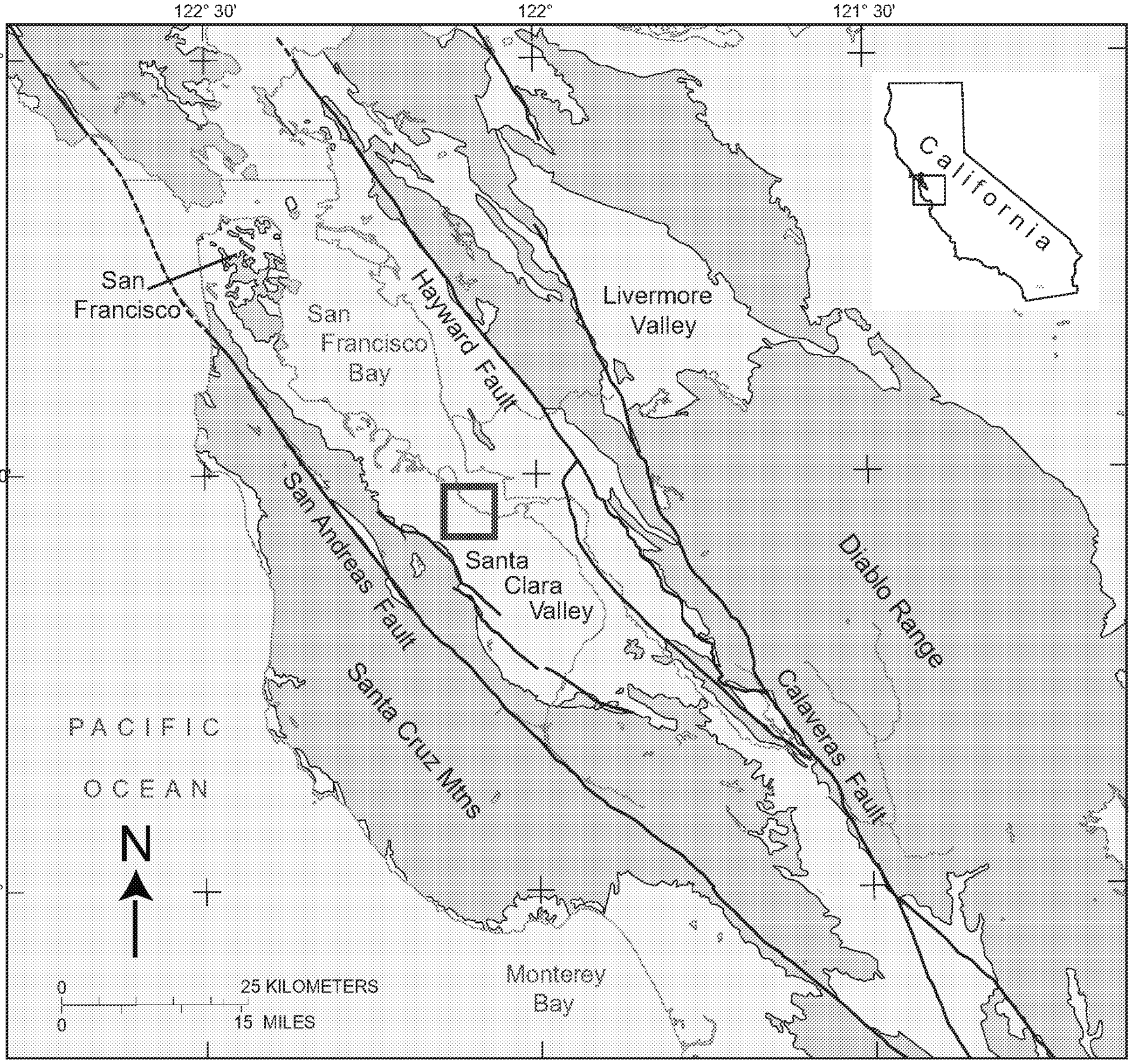
TRW 825
AMD 901/902
Philips
AMD 915
OOU

Zone B1 TCE 2013

Map showing Triple Site Groundwater Plume, contributing source area sites and responsible parties.

BURNS McDONNELL

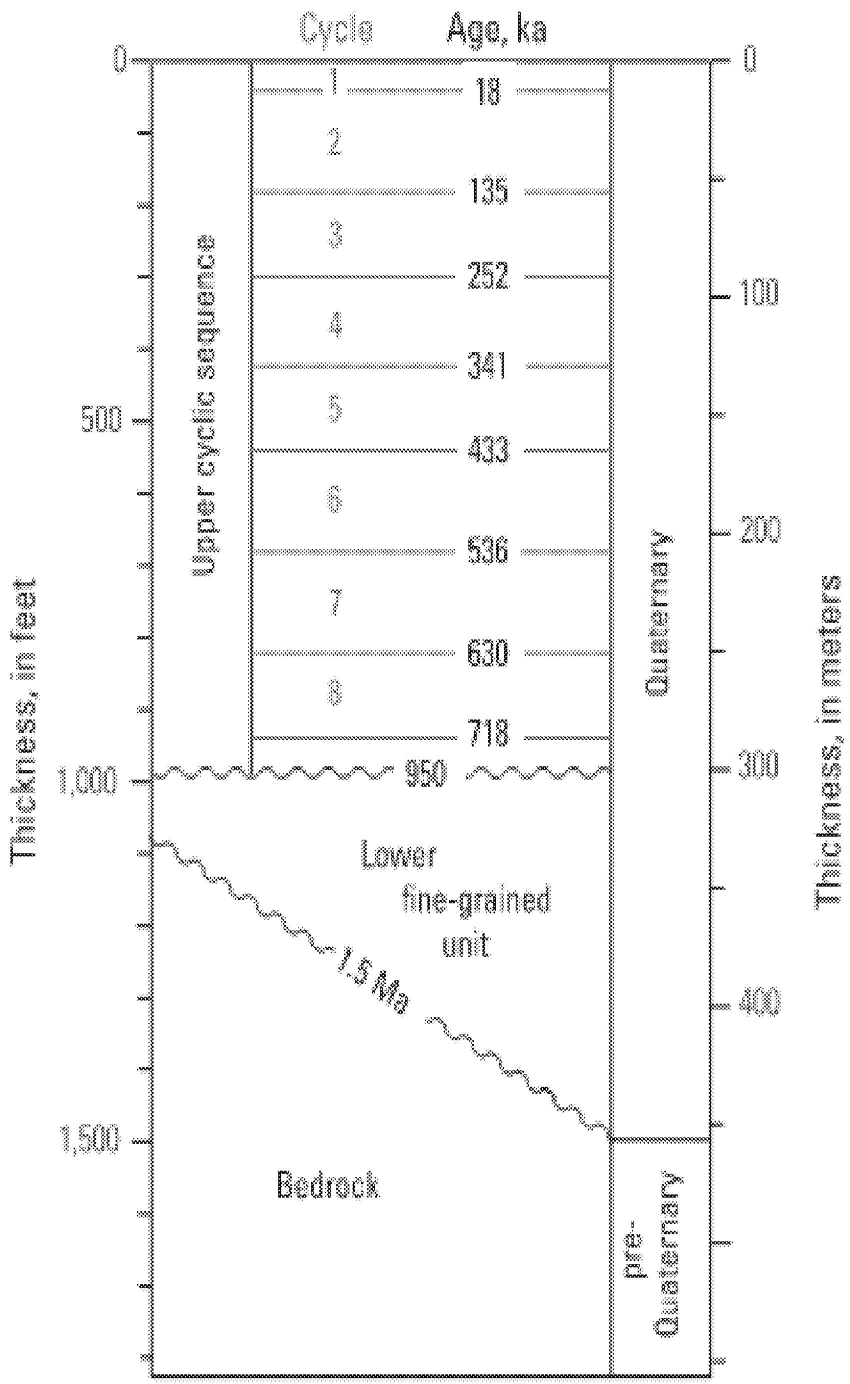
Figure 1
Triple Site Groundwater Plume
Former TRW Microwave Site
Sunnyvale, California



Map showing location of the Santa Clara Valley in the southern San Francisco Bay region, California. Alluvial lowlands (yellow) are distinguished from bedrock uplands (green). Principal faults are shown in black. Red box indicates general location.

BURNS McDONNELL

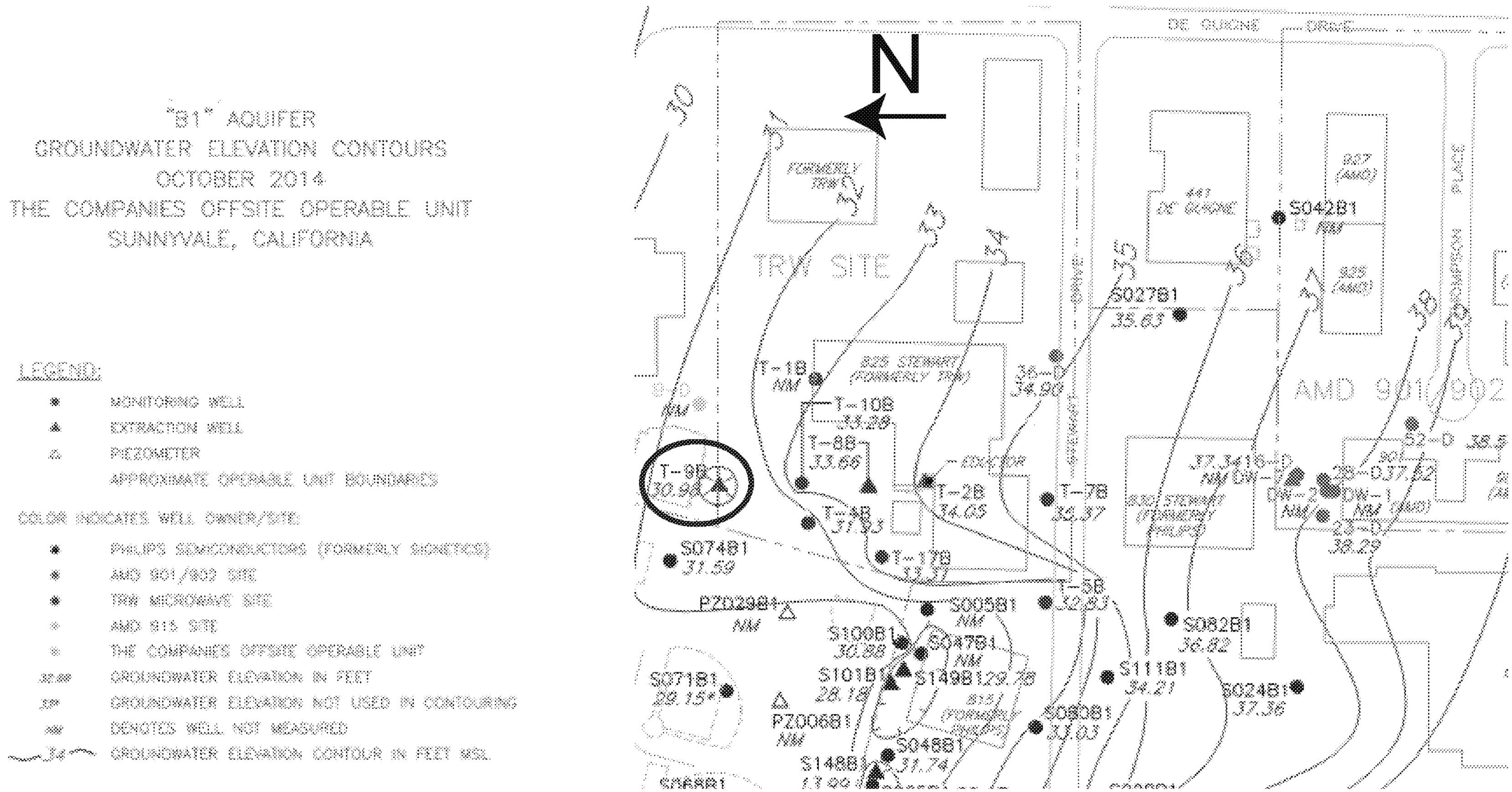
Figure 2
Site Location Map
Former TRW Microwave Site
Sunnyvale, California



Stratigraphic diagram showing subdivision of the Quaternary sedimentary fill of the Santa Clara Basin. Ages in thousands of years (ka) except where noted. Bedrock consists of Miocene fill of the Cupertino Basin, Miocene(?)-Pliocene fill of the Evergreen Basin, and rocks of the Franciscan Complex and Coast Range Ophiolite. Ages modified from Wentworth and Tinsley (2005a) and Wentworth and other (2010).

BURNS McDONNELL

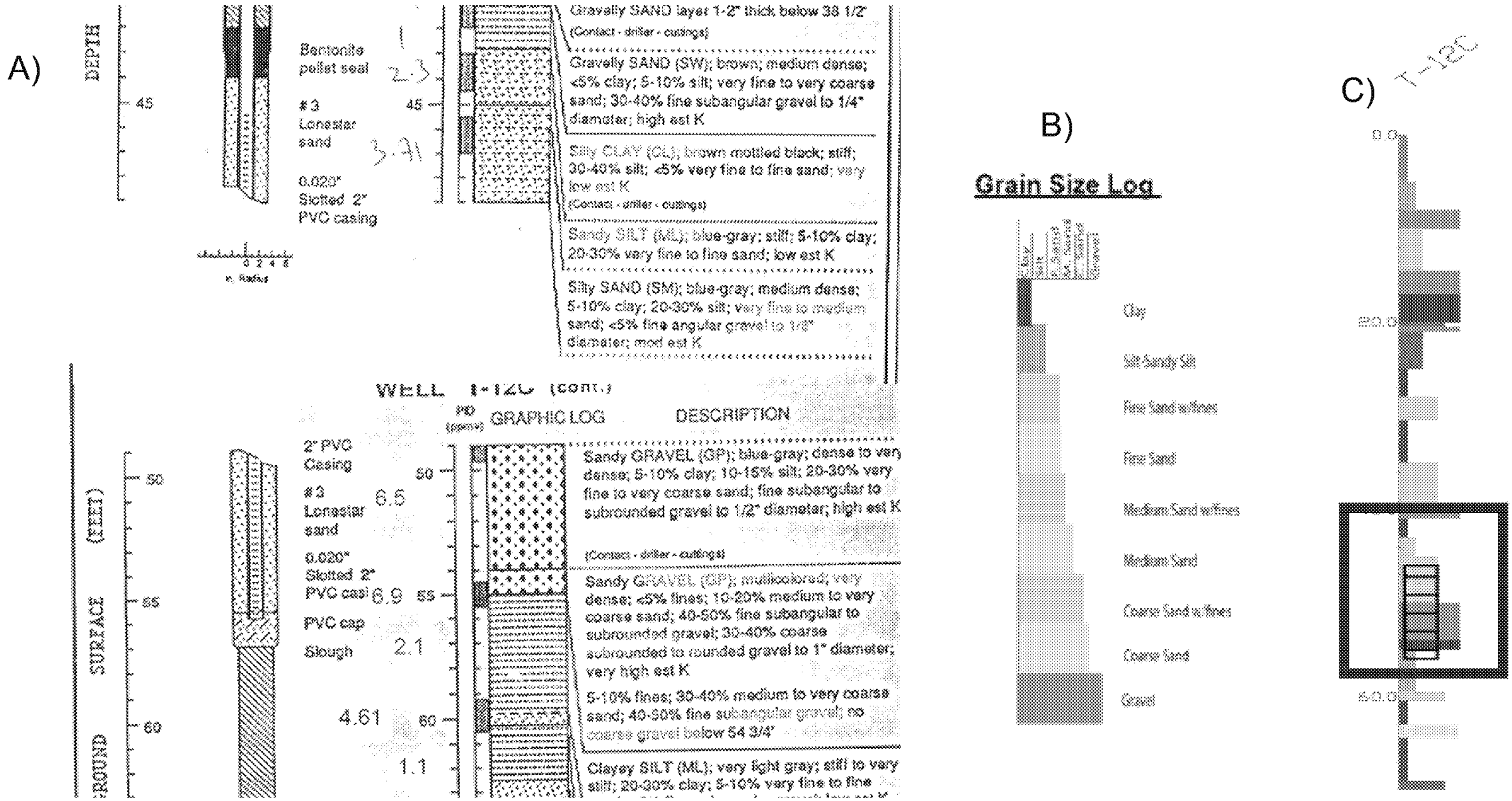
Figure 3
Stratigraphic Subdivision of the Santa Clara Basin
Former TRW Microwave Site
Sunnyvale, California



Potentiometric surface for "B1 Aquifer", October 2014. Note T-9B is indicated as an extraction well due to historic activity but was not active. Dashed arrow indicates apparent groundwater flow direction based solely on potentiometric contours. This map led authors of the 5YR to suspect residual source material at TRW Microwave was responsible for increasing concentrations of TCE at T-9B.

BURNS McDONNELL

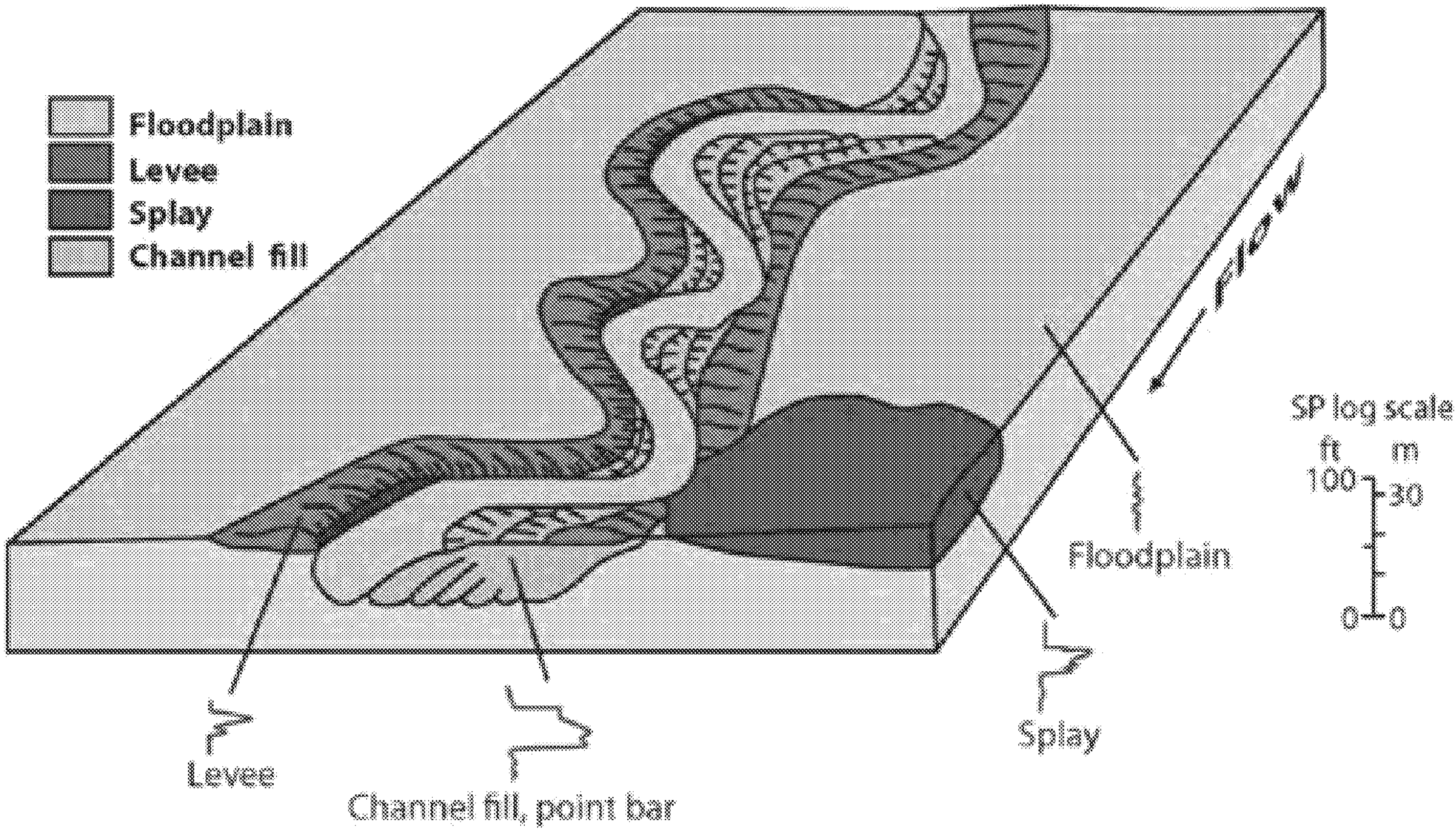
Figure 4
Potentiometric Surface for B1 Aquifer
Former TRW Microwave Site
Sunnyvale, California



A) Boring log for T-12C showing typical fining-upward sequence recorded in boring log data for the Site. The boring log shows a basal clayey silt overlain sharply by a sandy gravel. Grain size decreases vertically, both in the sand fraction and in the gravel fraction, and a progression from sandy gravel to silty sand, silt, and ultimately clay. The fining-upward sequence is the result of lateral migration of a fluvial channel.
B) Legend for Graphic Grain Size Logs (GSLs) created to perform initial ESS evaluation at the site.
C) GSL showing the graphic representation in log form for T-12C. The portion of the log in the red box corresponds to the boring log shown in (A).

BURNS McDONNELL

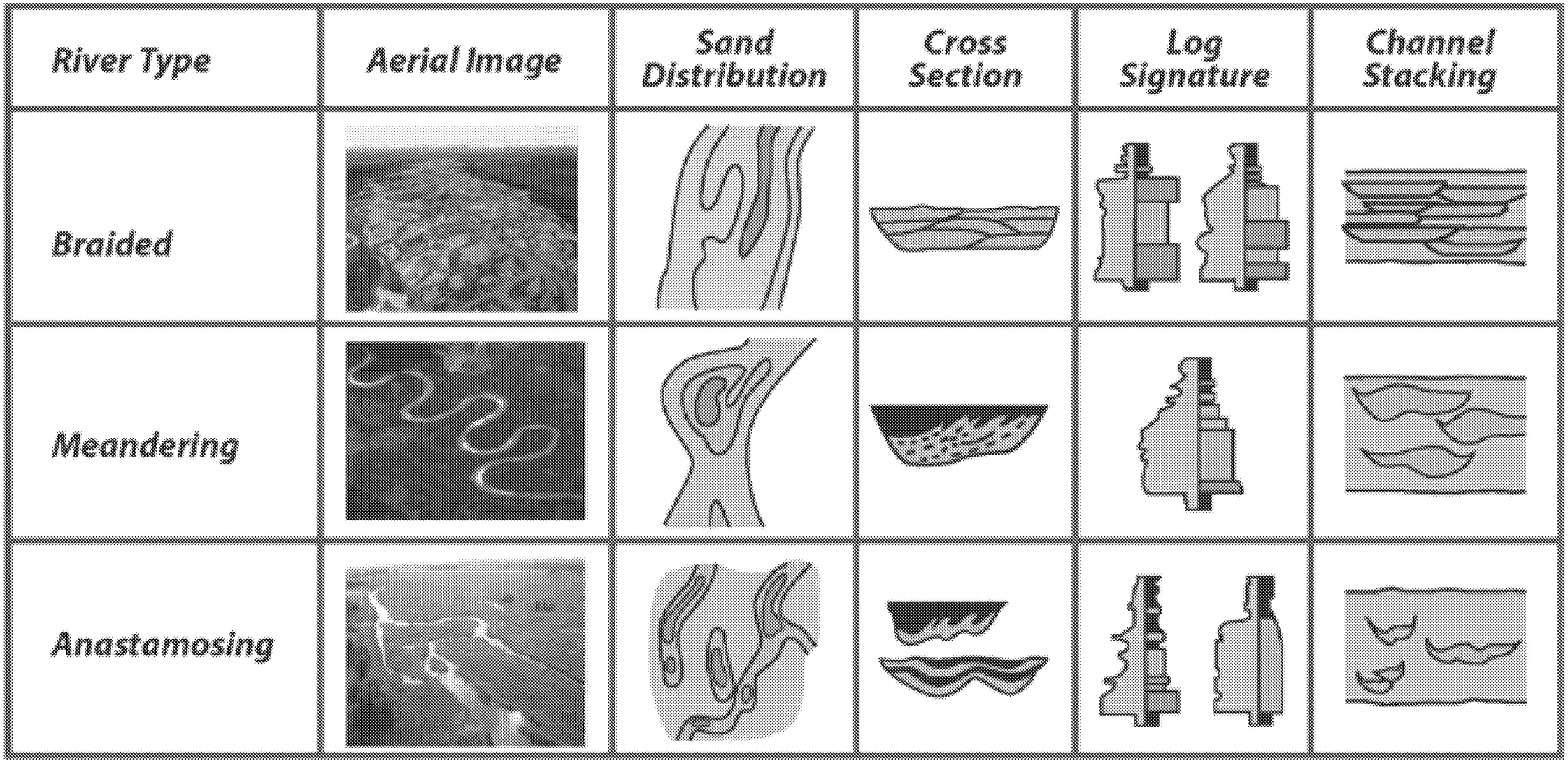
Figure 5
Boring Log for T-12C
Former TRW Microwave Site
Sunnyvale, California



Block diagram illustrating lateral migration of an anastomosing channel showing primary depositional elements and their associated log signatures. Block diagrams such as this one are referred to as facies models.

BURNS McDONNELL

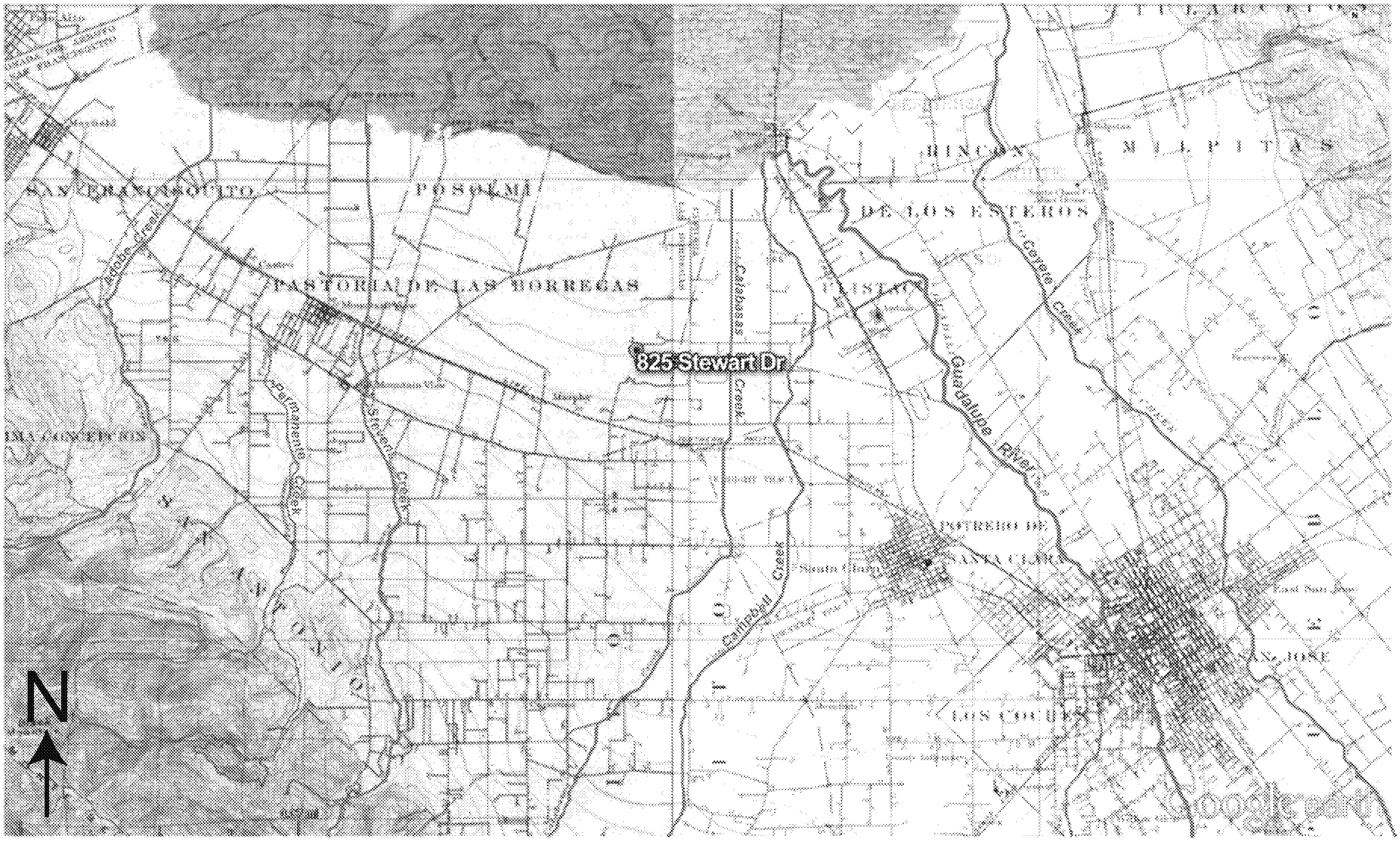
Figure 6
Facies Model for Anastomosing River System
Former TRW Microwave Site
Sunnyvale, California



General classification of fluvial systems and their deposits
(Bureau of Economic Geology, University of Texas at Austin).

BURNS McDONNELL

Figure 7
Classification of Fluvial Systems
Former TRW Microwave Site
Sunnyvale, California



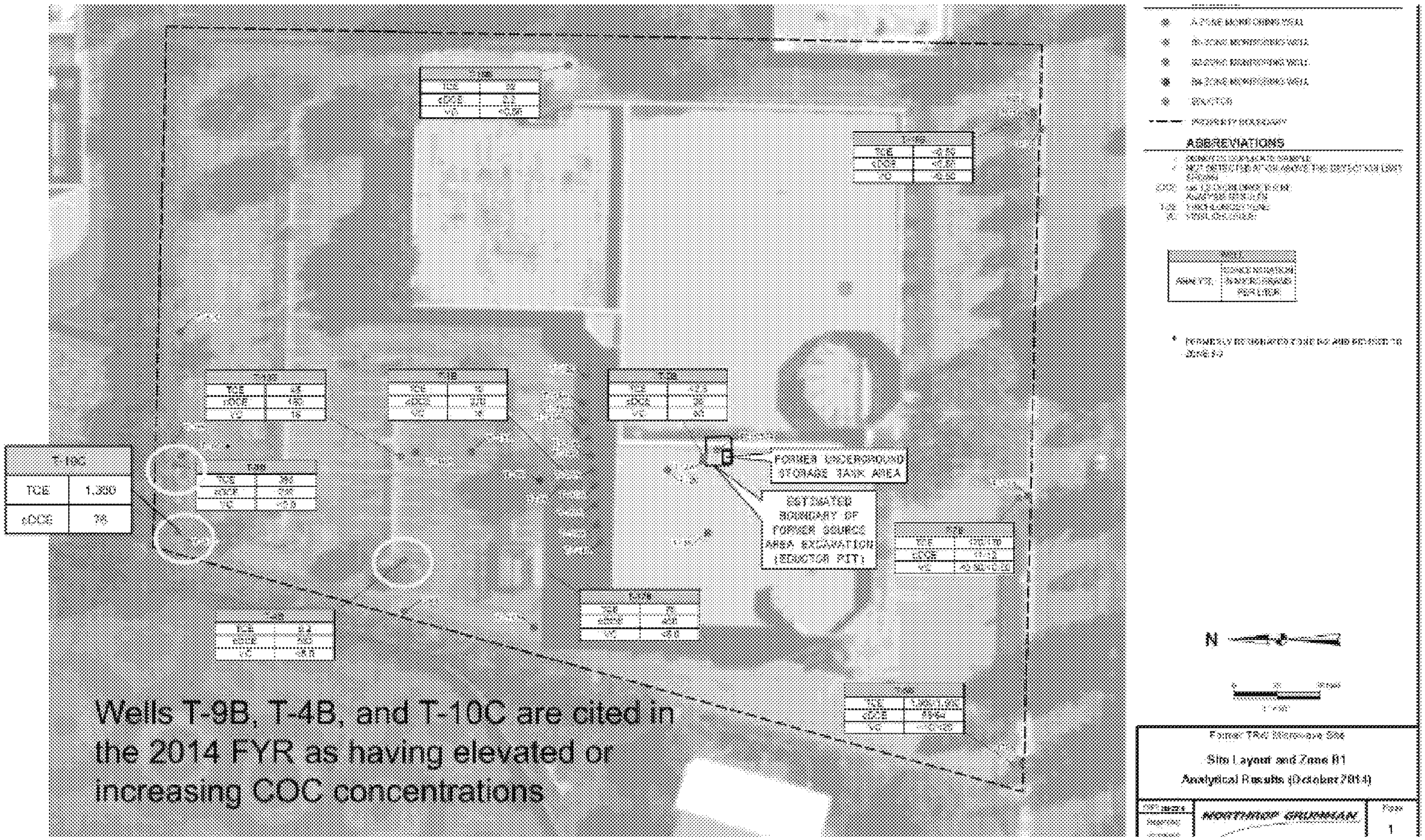
Historic topographic maps with stream courses highlighted in blue (United States Geological Survey).

BURNS McDONNELL

Figure 8
Historic Topographic Maps with Stream Courses
Former TRW Microwave Site
Sunnyvale, California

Potential Impact from Off-Site Sources

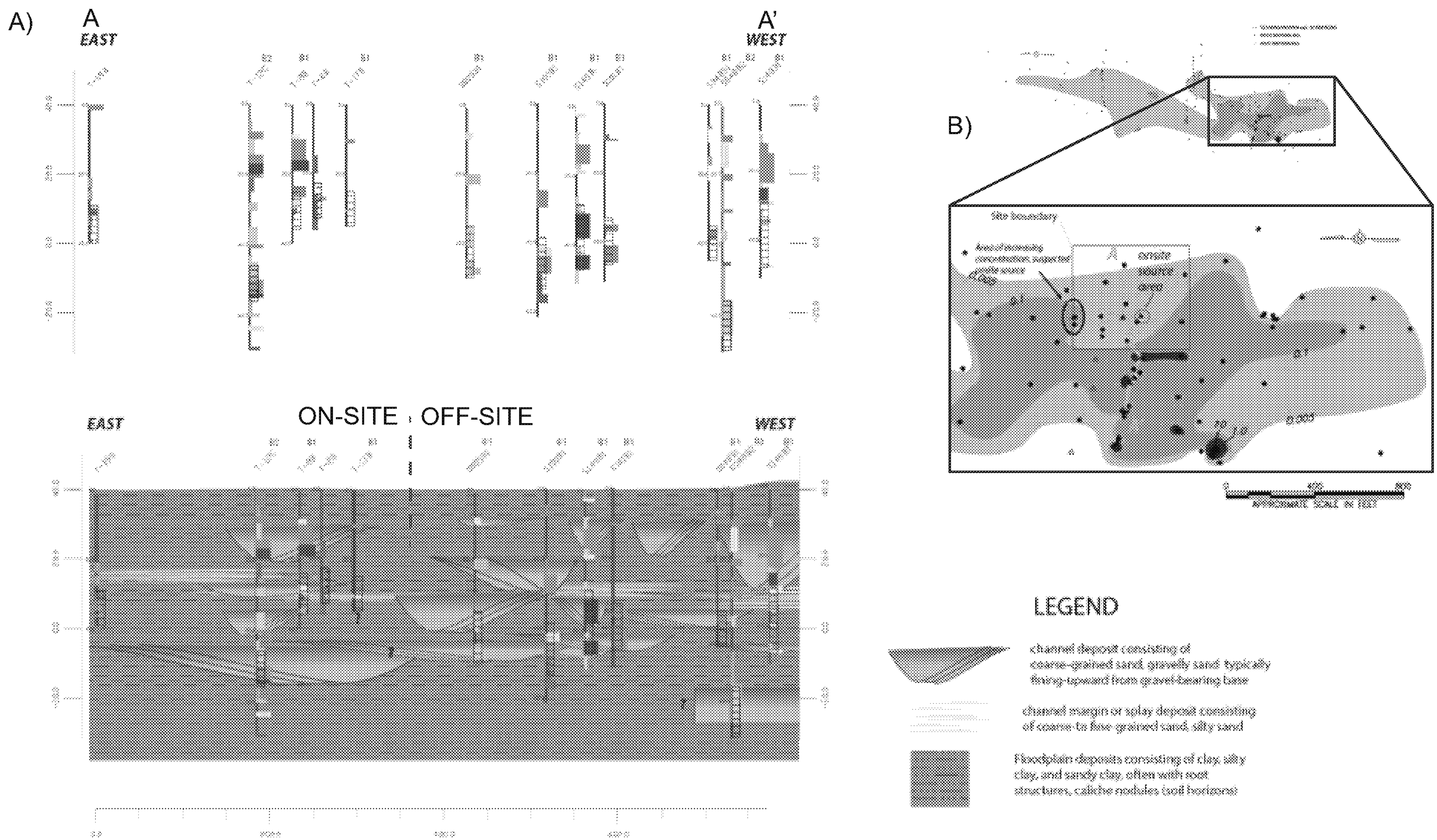
NORTHROP GRUMMAN



Site layout (2014) showing distribution of well logs used in initial ESS analysis.

BURNS McDONNELL

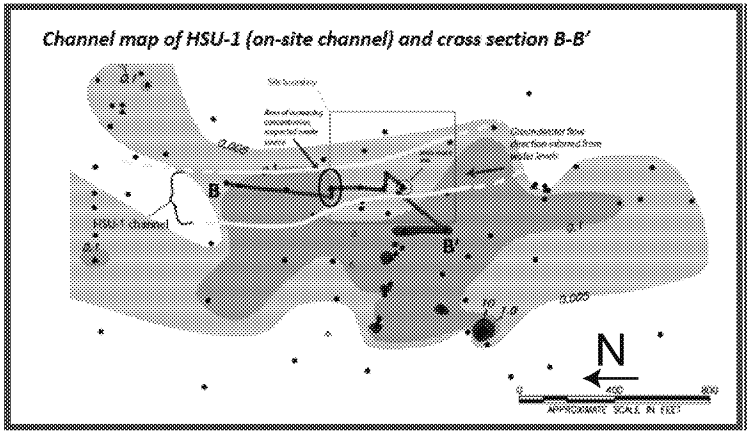
Figure 9
Site Layout (2014) Showing Distribution of Well Logs
Former TRW Microwave Site
Sunnyvale, California

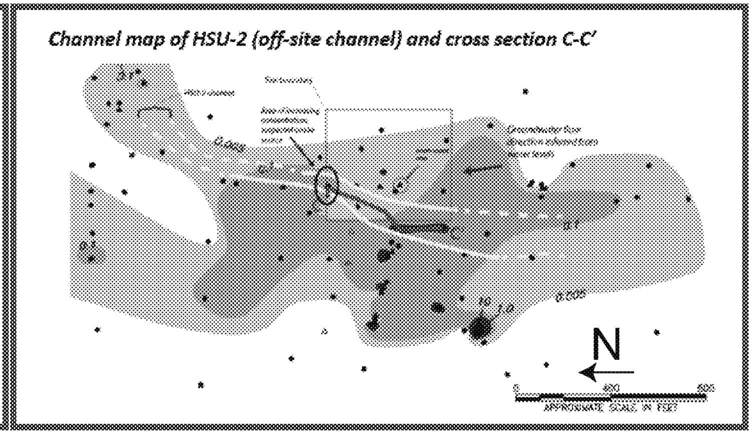


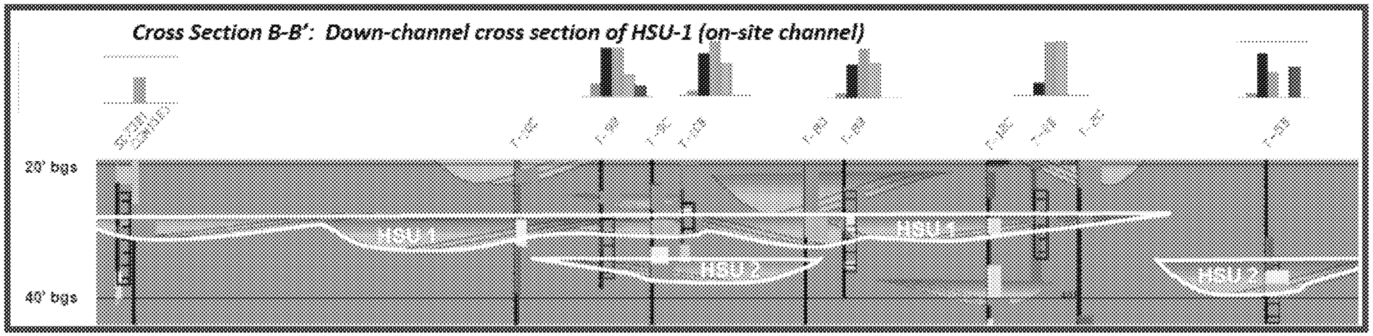
A) Uninterpreted (top left) and interpreted Cross Section A-A' illustrating channelized nature of aquifers at the Site. General groundwater flow is out of the plane, to the left on the index map (north). Historic aquifer zone designations (B1 and B2) are shown above well label in cross section. Hydrostratigraphic units 1 and 2 (HSU-1 and HSU-2) within the B1 depth zone are highlighted. B) Index map showing cross section location.

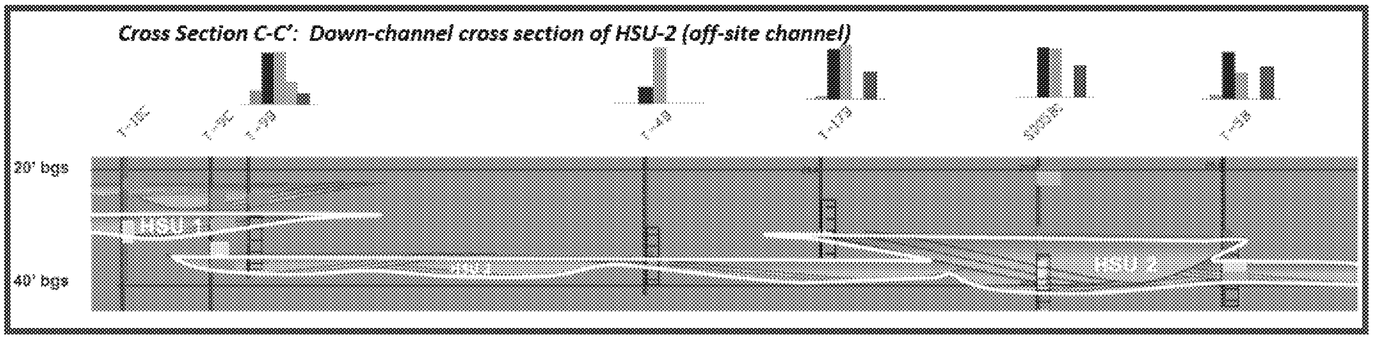
BURNS McDONNELL

Figure 10
Cross Section Illustrating
Channelized Aquifer
Former TRW Microwave Site
Sunnyvale, California

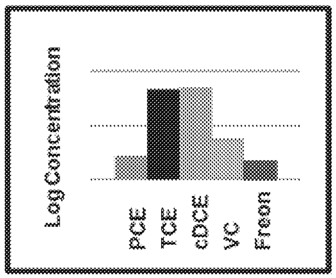








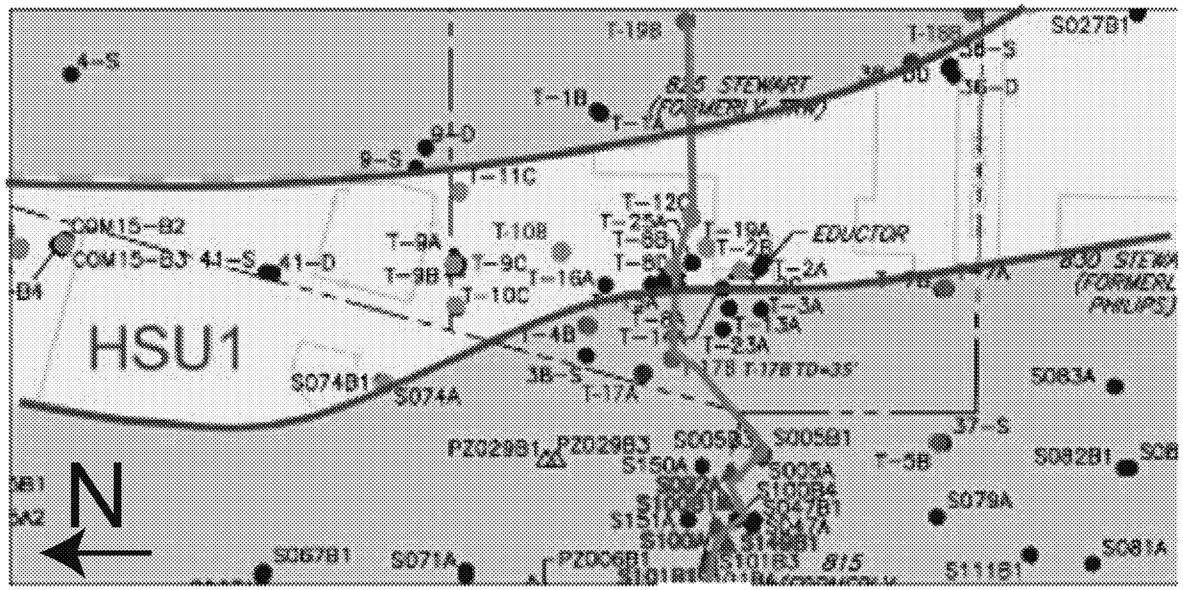
The results of the initial ESS analysis mapped two principal channel deposits at the Site representing hydrostratigraphic units (HSUs). HSU1 represents an on-Site channel connecting the former TRW source area with downgradient well T-9B in the area identified as an issue in the 5YR. Cross Sections B-B' and C-C' illustrate continuity of HSU-1 and HSU-2, respectively, and bar graphs illustrate contaminant fingerprints associated with each HSU. Note presence of Freon-113 in HSU-2, absence of VC in HSU-2, prevalence of VC and absence of Freon-113 in HSU-1, and presence of all analytes in T-9B, which is screened across both HSU-1 and HSU-2 and thus represents a mixture of the contaminants in both HSUs. See text for additional discussion.

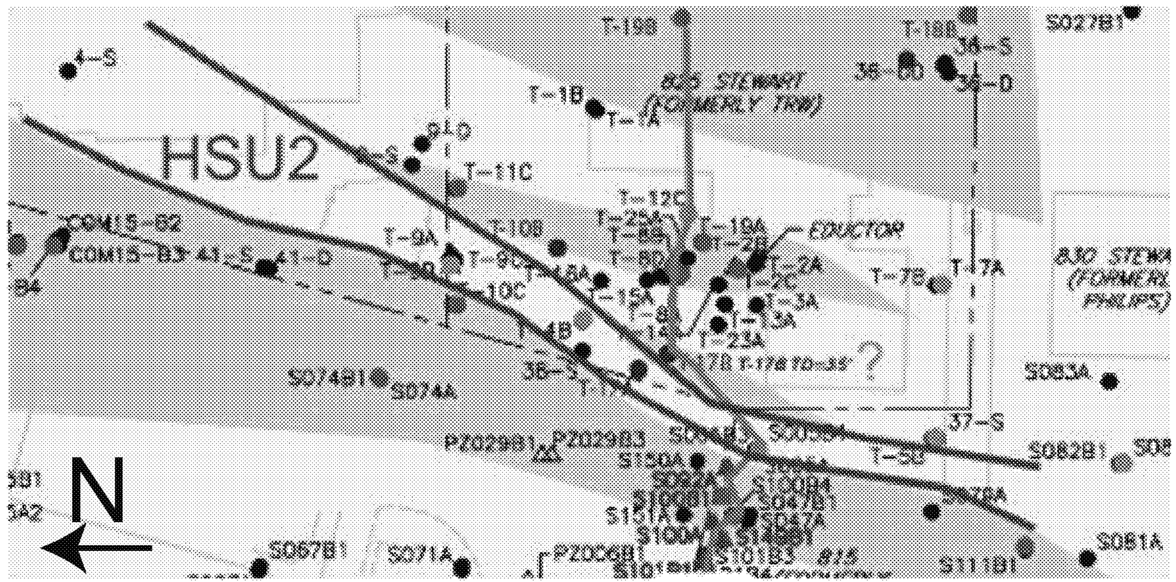


BURNS McDONNELL

Figure 11
Cross Sections and Maps of HSU-1 and HSU-2
Former TRW Microwave Site
Sunnyvale, California

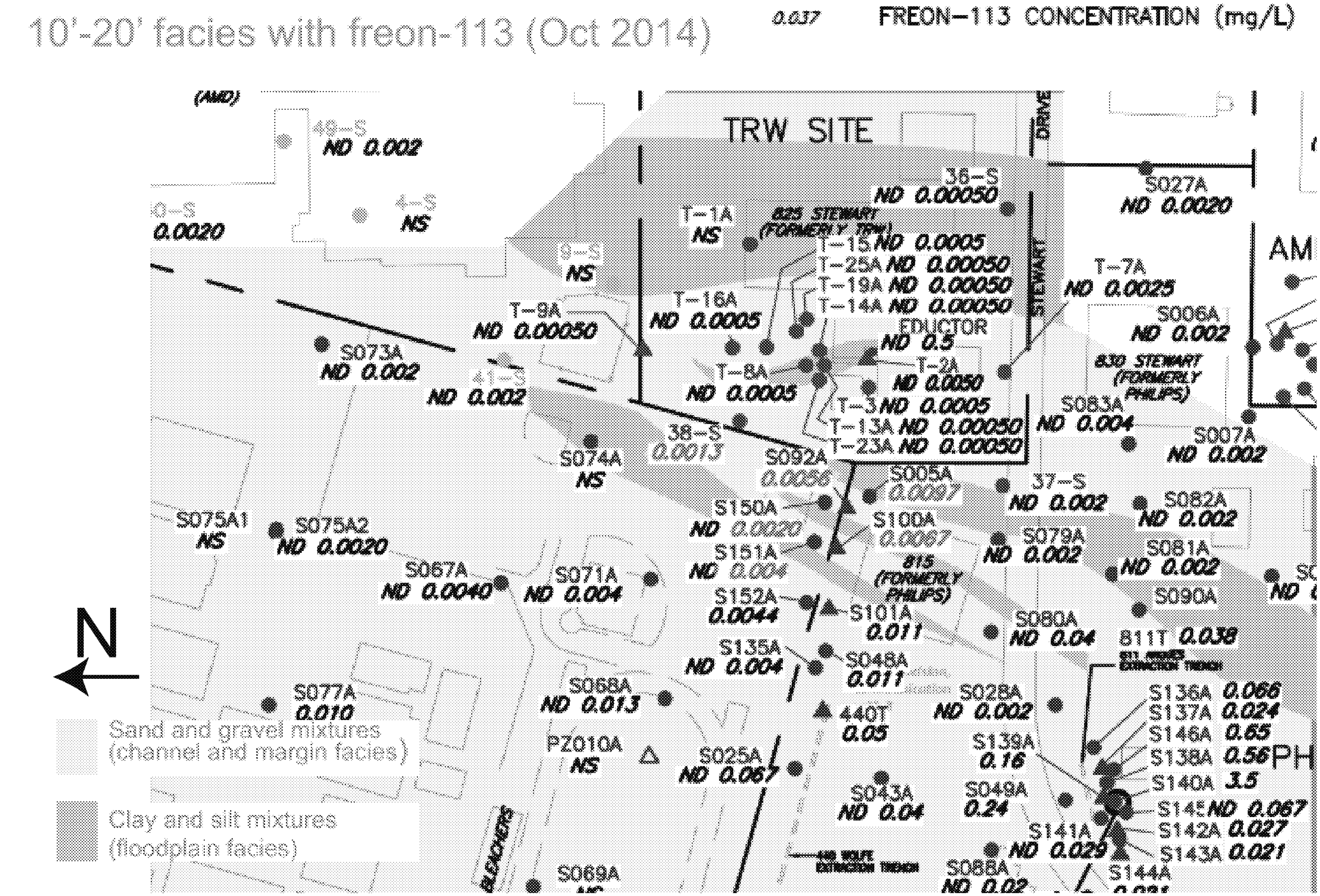
2015 interpretation of HSU-1 (on 30'-35' bgs facies map) and HSU-2 (on 35'-40' bgs facies map).





BURNS McDONNELL

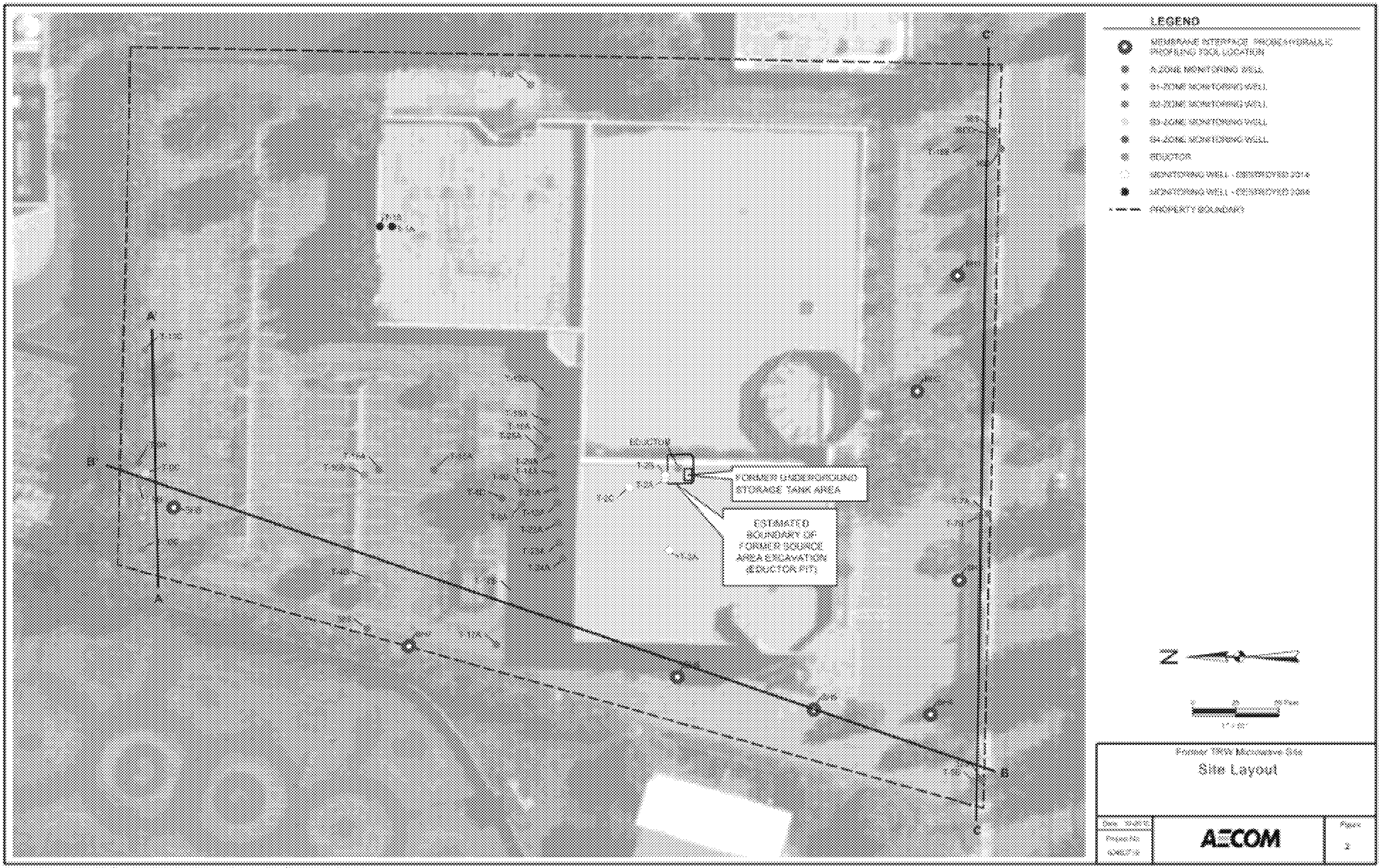
Figure 12
Facies Maps of HSU-1 and HSU-2
Former TRW Microwave Site
Sunnyvale, California



Facies map 10'-20' bgs with Freon-113 concentration values (mg/L), October 2014. High concentrations being carried onto TRW from Philips are highlighted in yellow.

BURNS McDONNELL

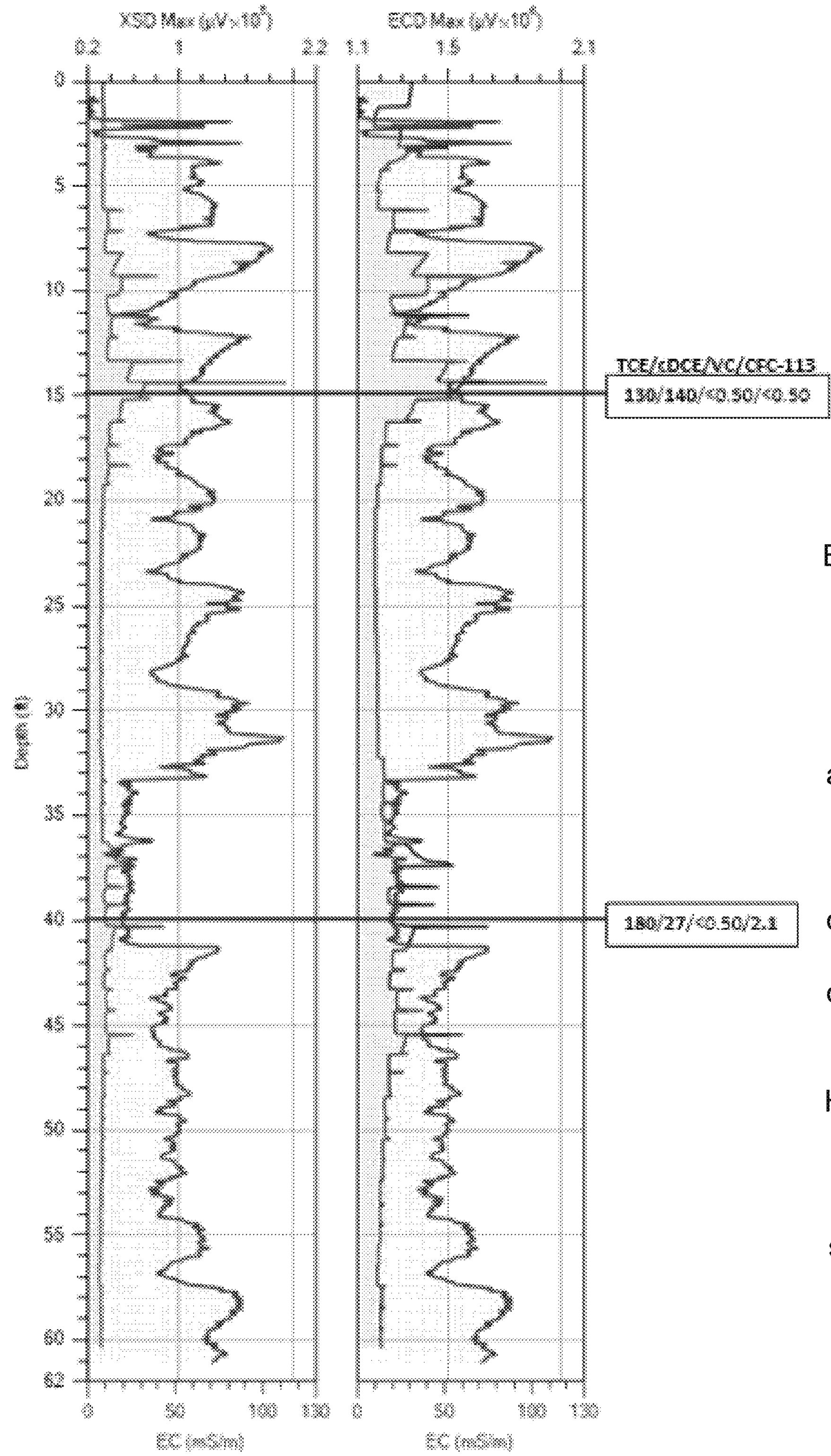
Figure 13
Facies Map of A Zone Sand
Former TRW Microwave Site
Sunnyvale, California



Locations of MIP/HPT data collection points for 2016 field data collection event.

BURNS McDONNELL

Figure 14
Map of 2016 MIP / HPT Locations
Former TRW Microwave Site
Sunnyvale, California



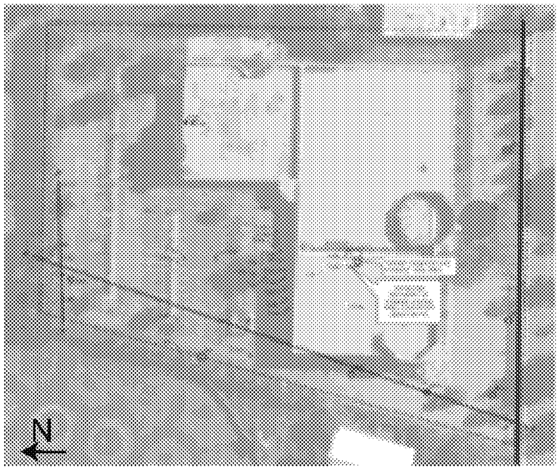
Electrical conductivity, XSD, and ECD tracks from B-3 MIP/HPT log with hydropunch sample points and analytical data. Conductivity shifts to the left (low) indicate permeable zones. Note blocky sand from 42-33' bgs and XSD and ECD response in this interval indicating presence of contamination, confirming that channel sands are the contaminant pathways at the site. Also note presence of TCE, cDCE, and Freon-113 (CFC-113), and lack of VC in the channel deposit, which corresponds to HSU-2 (off-site channel pathway). In the shallower part of the stratigraphic section, XSD and ECD response in fine-grained strata indicate that contamination has invaded the matrix silts and clays.

ASC Tech Services

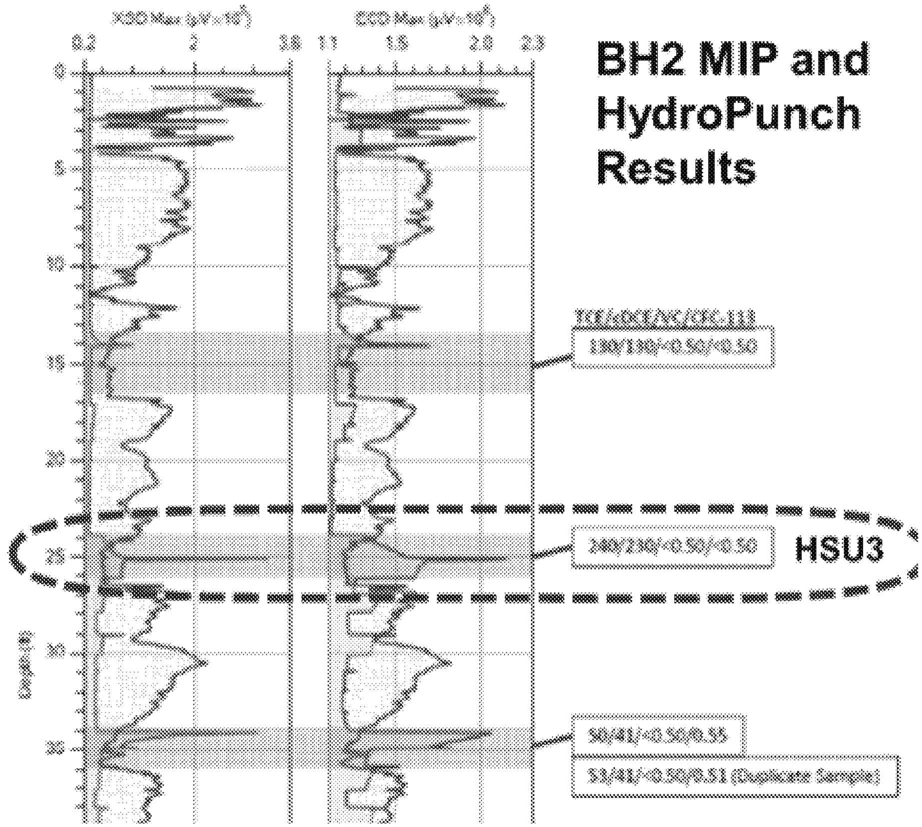
Company: ASC Tech Services	Operator: Eric W. Garcia (CHG786)	File: B-3 MIP / Date: 7/15/2018
Project ID: Former TRW Microwave Site	Client: AECOM	Location: 37° 23' 3" N, 122° 0' 38" W

BURNS McDONNELL

Figure 15
B-3 MIP / HPT Logs
Former TRW Microwave Site
Sunnyvale, California

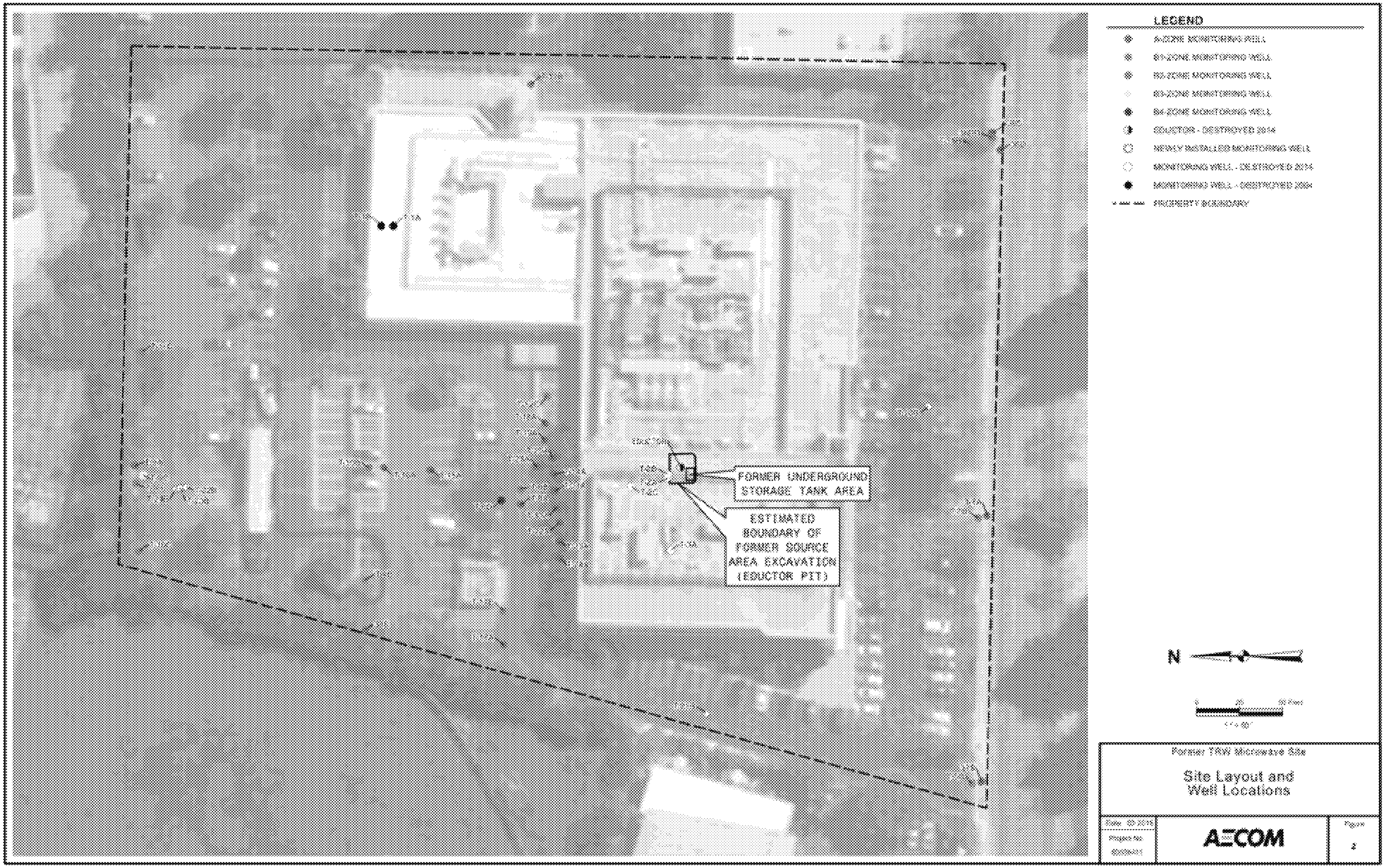


A) BH-2 location map (BH-2 shown as green dot).



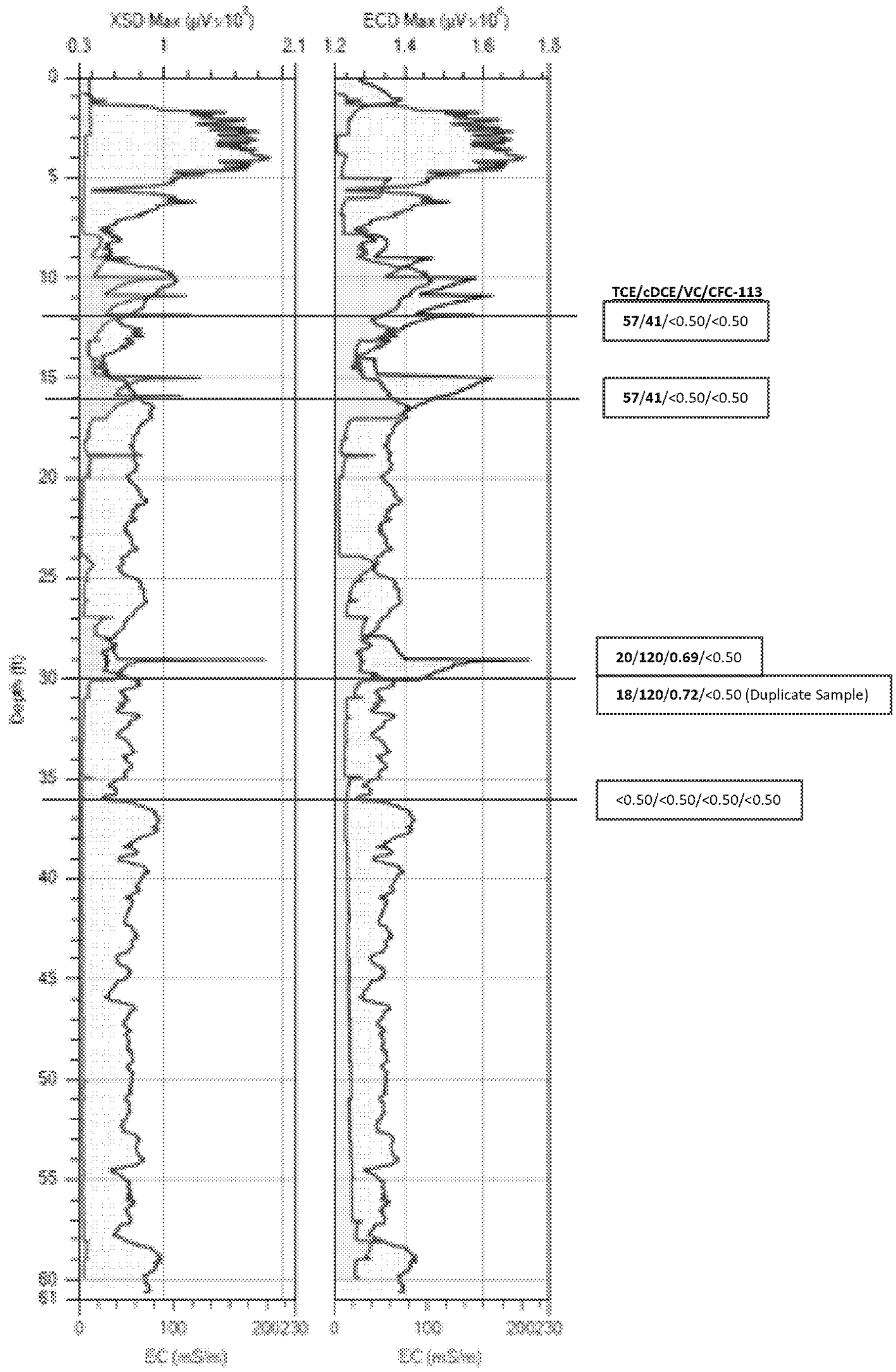
B) BH-2 MIP logs with conductivity log (yellow filled curve) showing newly identified HSU-3.

BURNS McDONNELL	Figure 16 BH2 MIP and HydroPunch Results Former TRW Microwave Site Sunnyvale, California



Site layout following well installation activities in 2017 and 2018 (from May 2018 Well Installation Report).

Figure 17
2017/2018 Well Installation Site Layout
Former TRW Microwave Site
Sunnyvale, California



Channels flushed, contamination in matrix (mature stage)

Permeable channels primary pathway, fines also significantly contaminated (mid-stage).

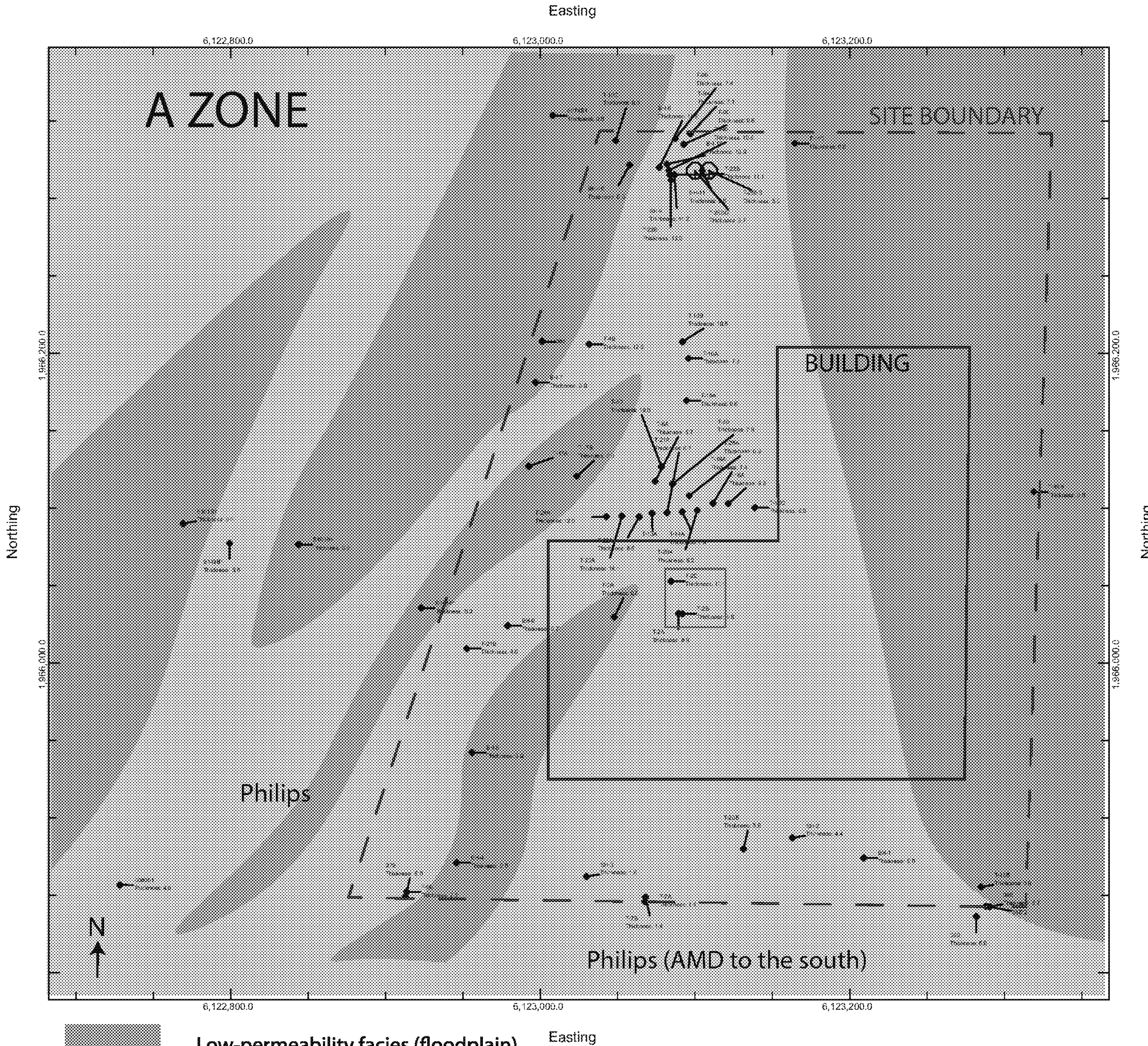
ASC Tech Services

Company:	Operator:	Date:
ASC Tech Services	Eric W. Garcia	7/14/2016
Project ID: Former TRW Microwave Site	Client: AECOM	Location: 37° 23' 7" N, 122° 0' 35" W

XSD and ECD response with EC logs. Contamination is apparent in HSU-1 channel deposit (contaminant transport zone) at 29' bgs, and contamination is also observed in fine-grained strata from 24'-35' indicating that matrix diffusion represents a source in this area. This is likely due to over a decade of groundwater extraction in this area which pulled contamination through fine-grained strata, charging it with contamination. Plume maturity – A zone is mature, B is mid-life crisis.

BURNS McDONNELL

Figure 18
BH-4 MIP Log
Former TRW Microwave Site
Sunnyvale, California



Low-permeability facies (floodplain)

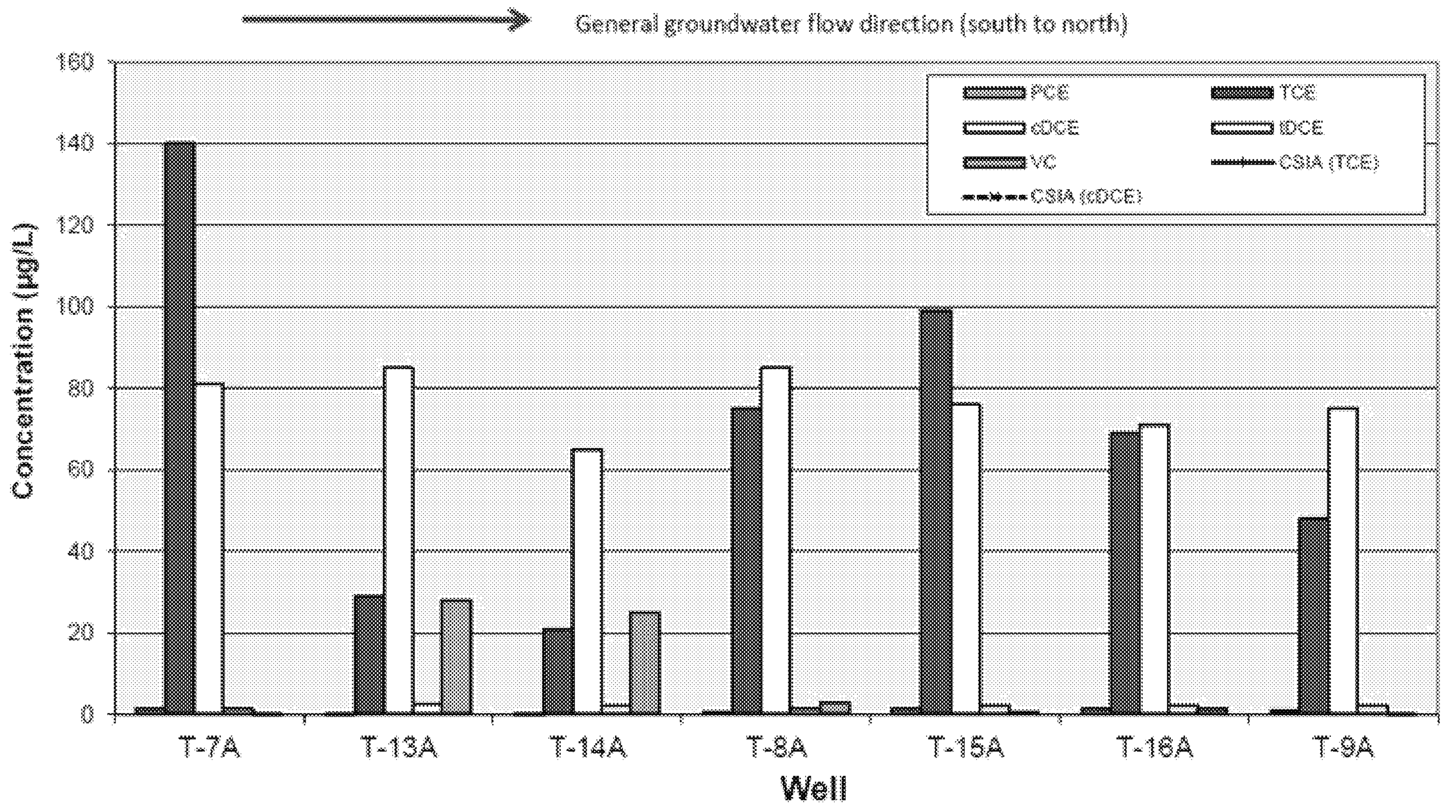
High-permeability facies (channel axis or margin / splay)

T-2 source area

"A Zone" facies map with control points and thickness of permeable channel facies, current interpretation (2020).

BURNS McDONNELL

Figure 19
A Zone Facies Map, 2020
Former TRW Microwave Site
Sunnyvale, California

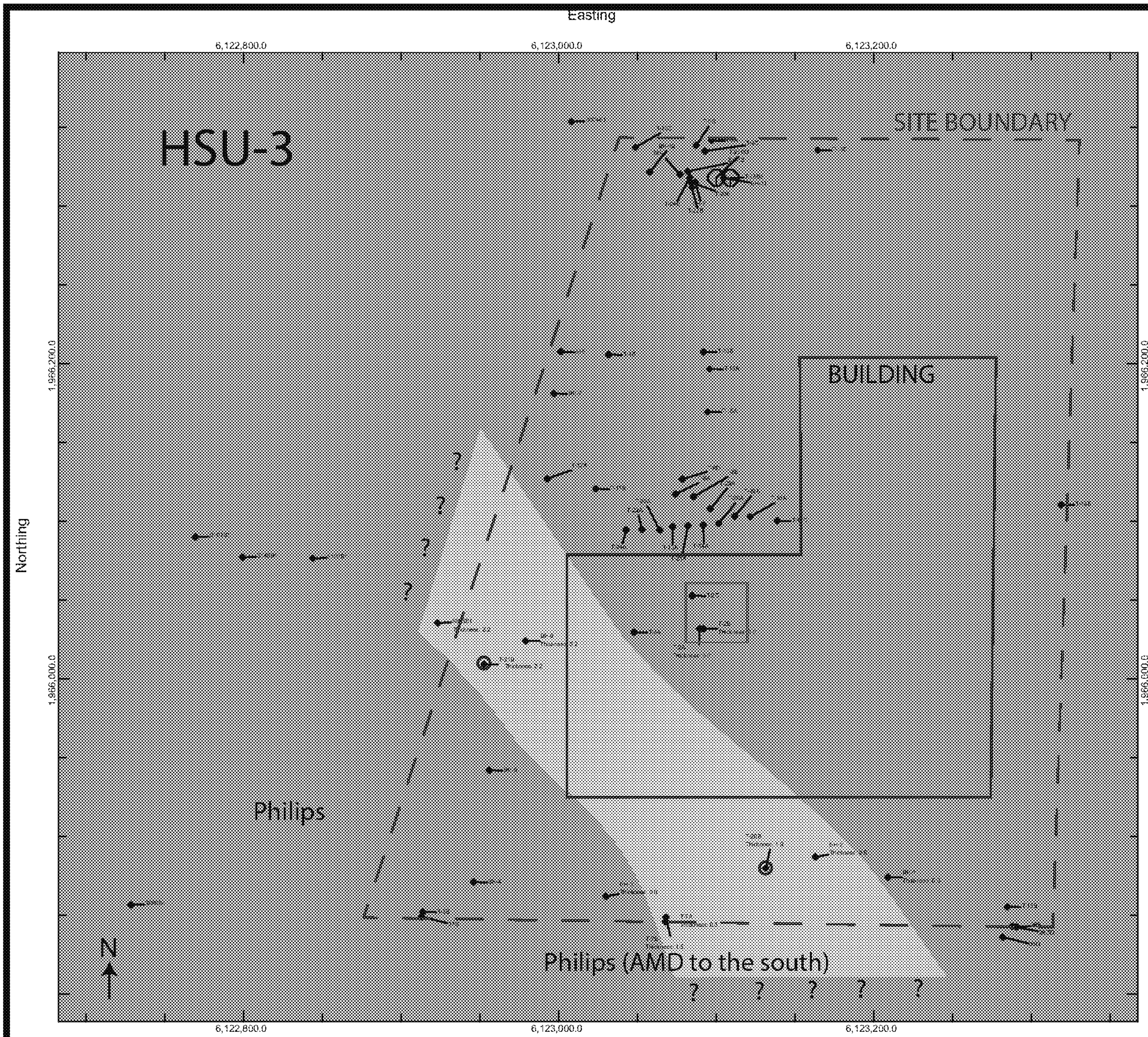


Note: Groundwater flow direction is generally along the wells listed above, from south to north, from onsite well T-7A to well T-9A.

Upgradient (south) to downgradient (north) concentration trends in A zone monitoring wells.

BURNS McDONNELL

Figure 20
A Zone Upgradient to Downgradient Concentration Trends - Oct. 2018
Former TRW Microwave Site
Sunnyvale, California



Low-permeability facies (floodplain)

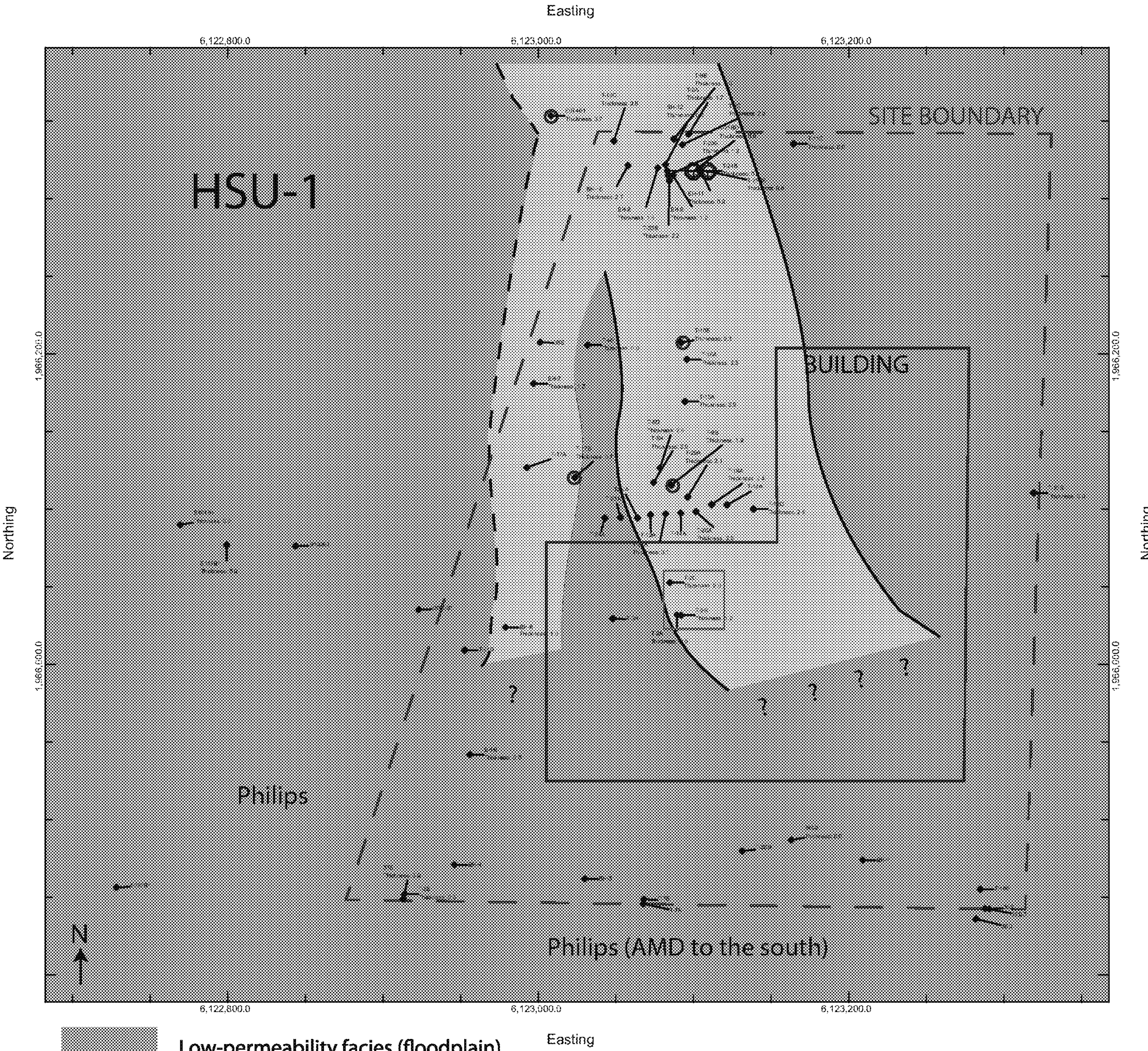
High-permeability facies (channel axis or margin / splay)

T-2 source area

Monitoring Well Screen intersecting HSU

BURNS McDONNELL

Figure 21
HSU-3 Facies Map
Former TRW Microwave Site
Sunnyvale, California



Low-permeability facies (floodplain)

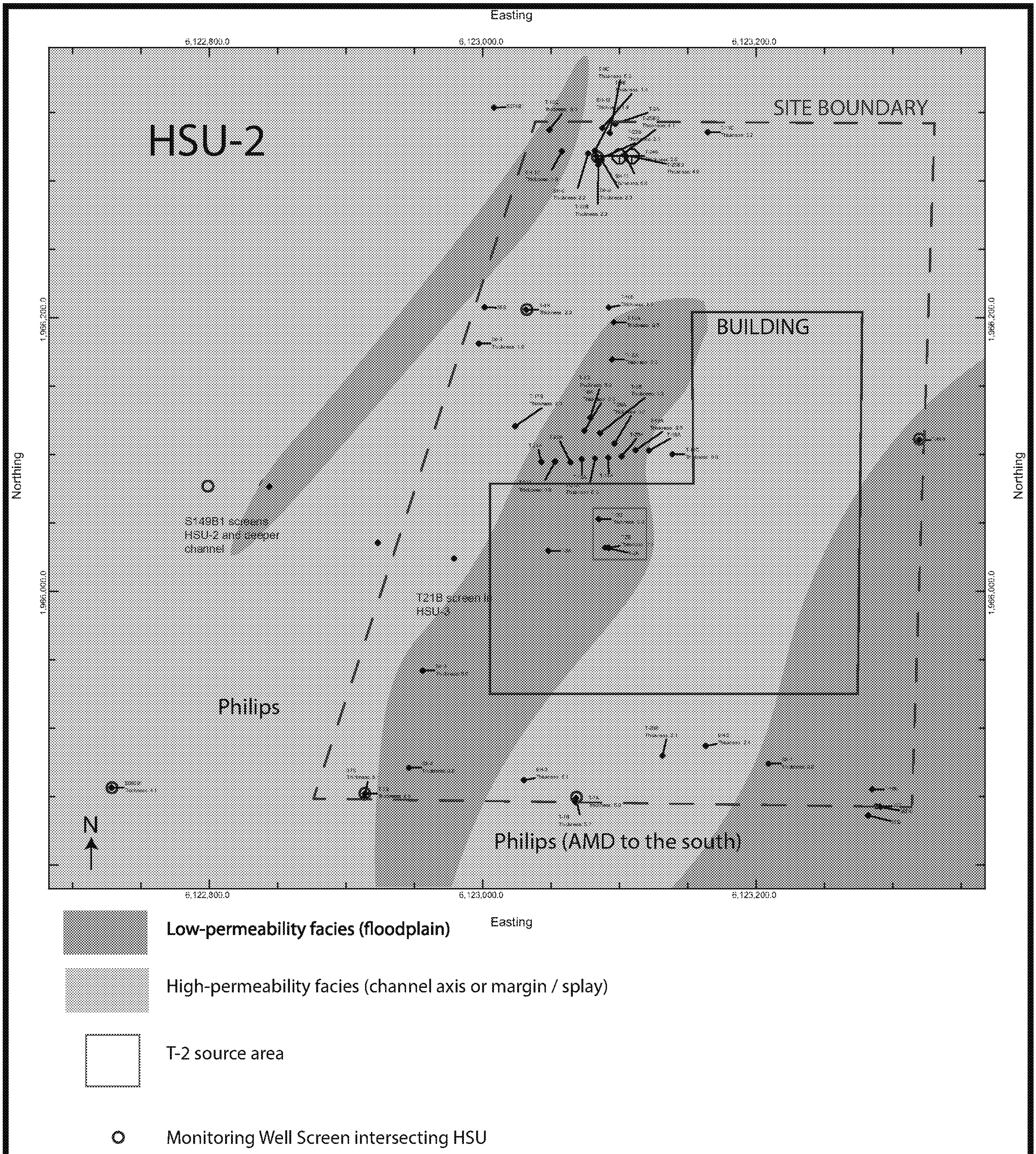
High-permeability facies (channel axis or margin / splay)

T-2 source area

Monitoring Well Screen intersecting HSU

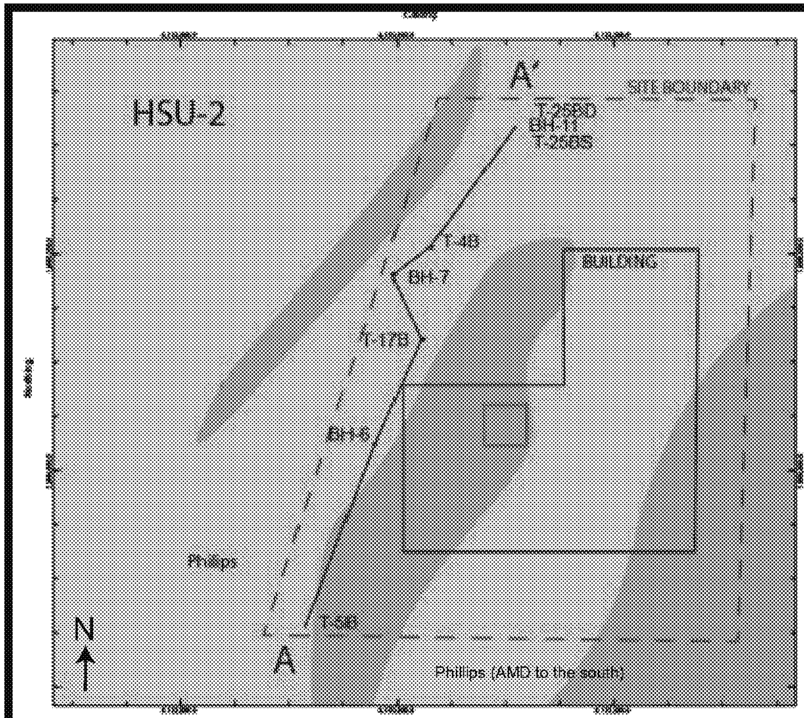
BURNS McDONNELL

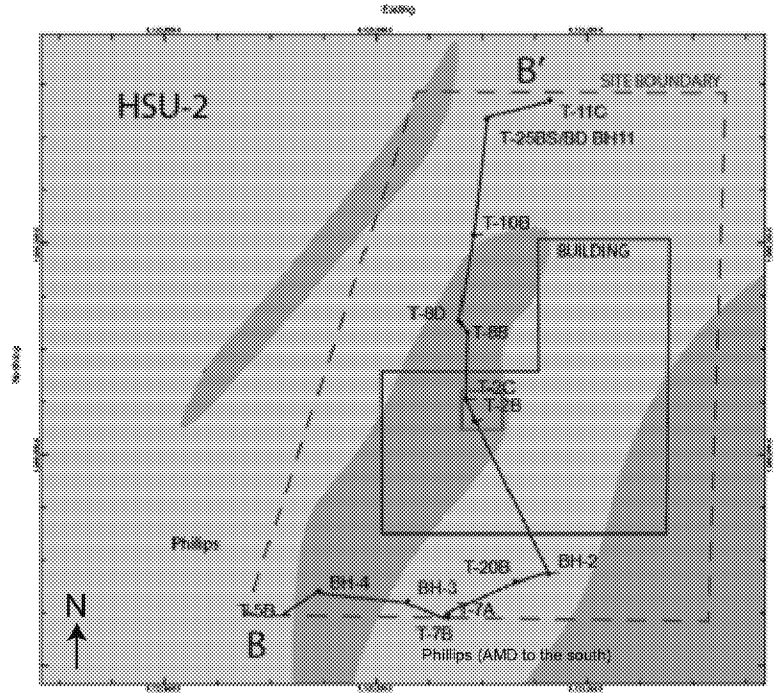
Figure 22
HSU-1 Facies Map
Former TRW Microwave Site
Sunnyvale, California

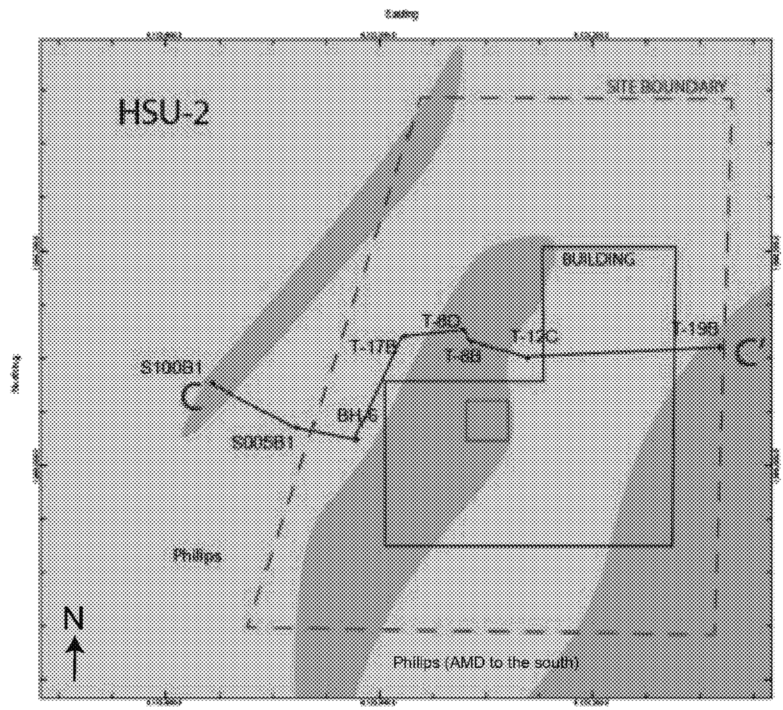


BURNS McDONNELL

Figure 23
HSU-2 Facies Map
Former TRW Microwave Site
Sunnyvale, California







Index map for geologic Cross Sections A, B, and C.

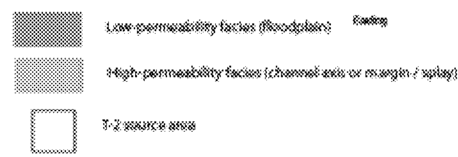
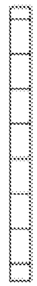
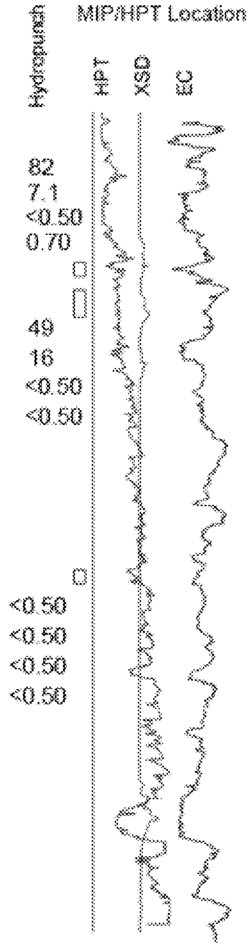


Figure 24
Index Maps for Geologic Cross Sections
Former TRW Microwave Site
Sunnyvale, California

Monitoring well or hydropunch screen and groundwater analytical data (Q4 2019 for MWs, date of install for MIP/HPT Hydropunch Samples

TCE	57
cis-1,2,DCE	1.3
VC	<0.50
Freon-113	1.2





Graphic Grain Size Legend

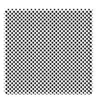
Width of log column denotes predominant grain size as described for that interval in boring log.

<u>Color in log column indicates following:</u>
red = gravelly (coarse)
orange = gravelly (fine-medium)
yellow = "clean" sand
green = silty
blue = clayey
Brown colors represent mixtures of sand, silt, and gravel in clayey matrix (i.e., diamicton in glacial till).
Blank intervals indicate no sample recovered.

LEGEND

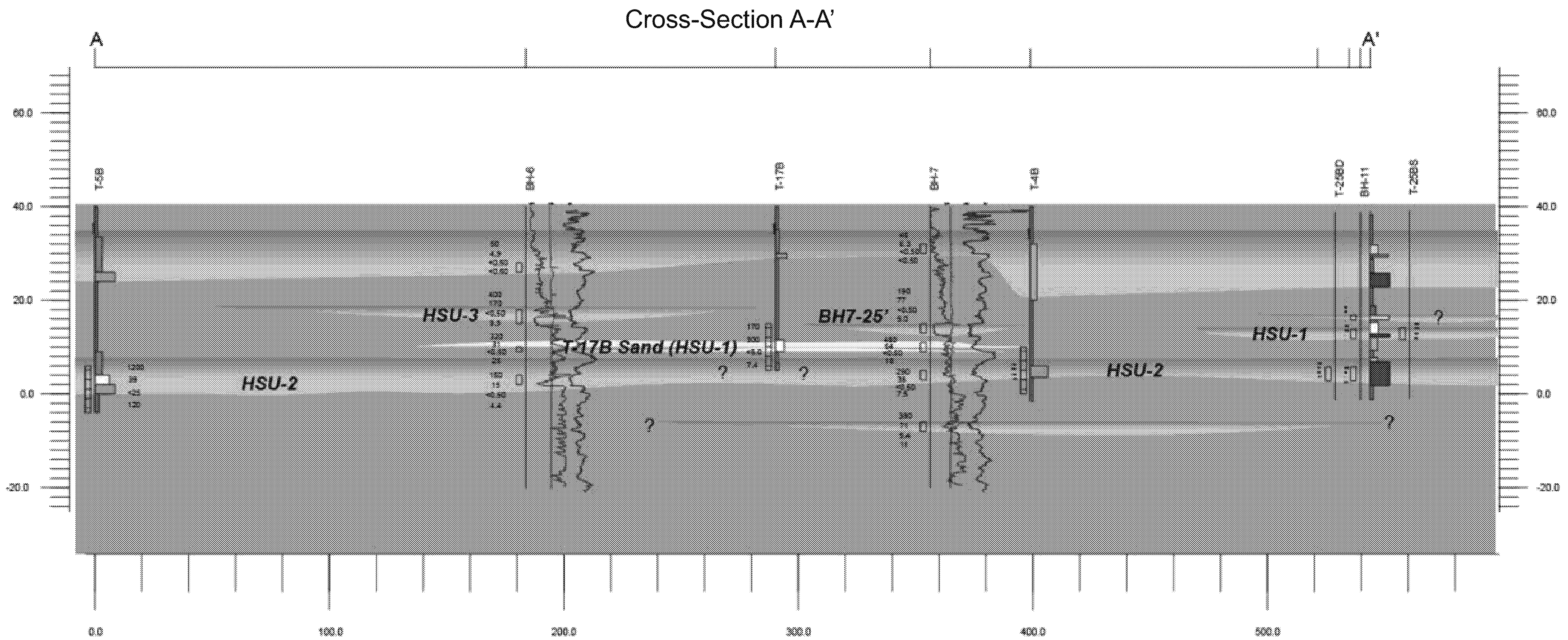

channel deposit consisting of coarse-grained sand, gravelly sand typically fining-upward from gravel base

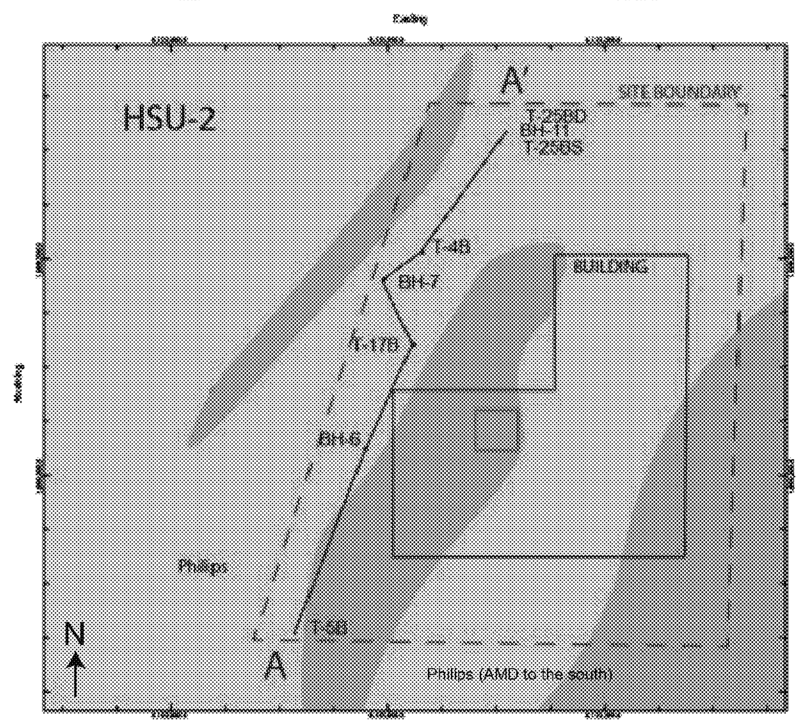

channel margin or splay deposit consisting of coarse-to fine-grained sand, silty sand


Floodplain deposits consisting of clay, silty clay, and sandy clay, often with root structures, caliche nodules (soil horizons)

BURNS McDONNELL

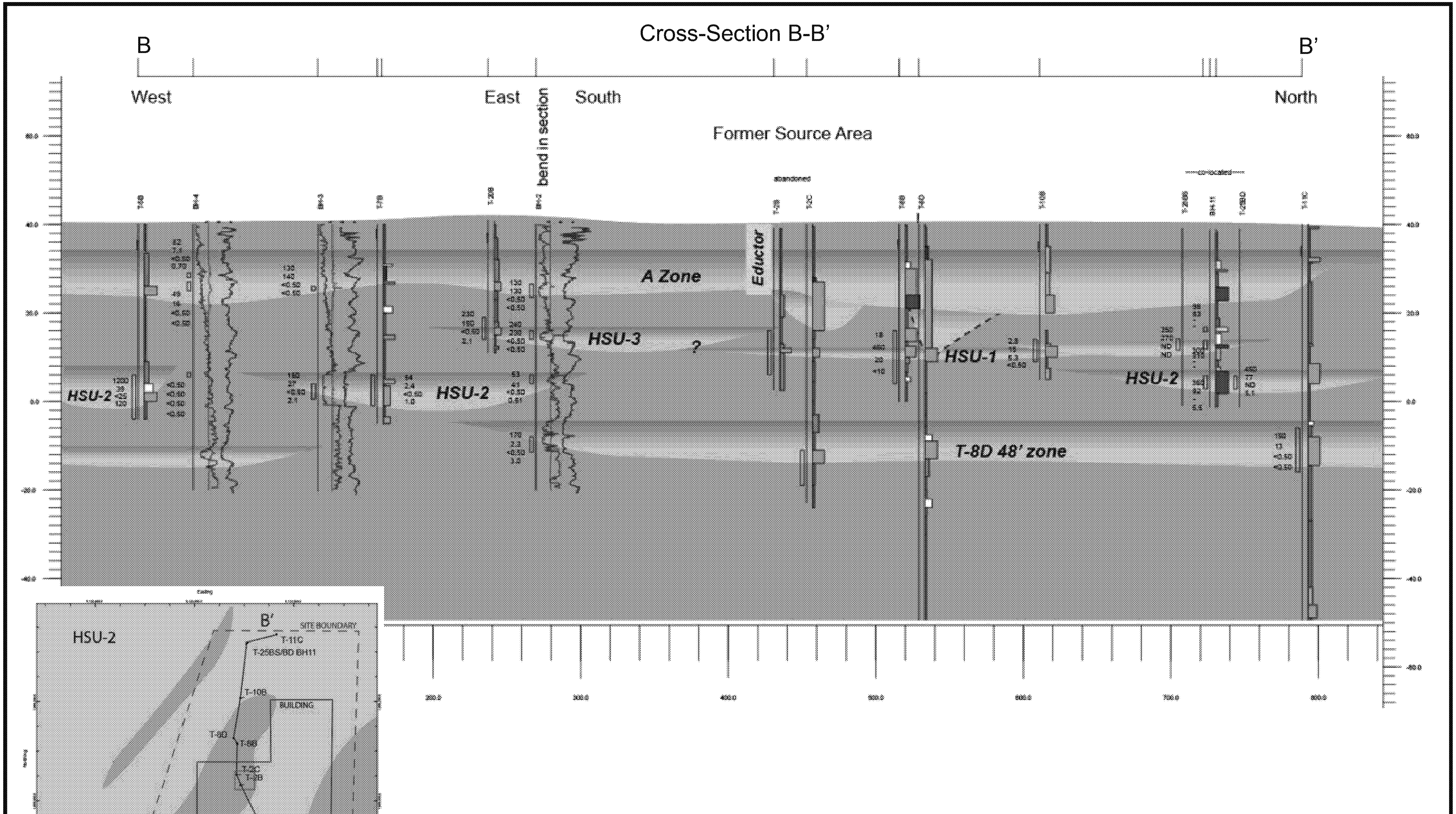
Figure 25
Geologic Cross Section
Explanation
Former TRW Microwave Site
Sunnyvale, California





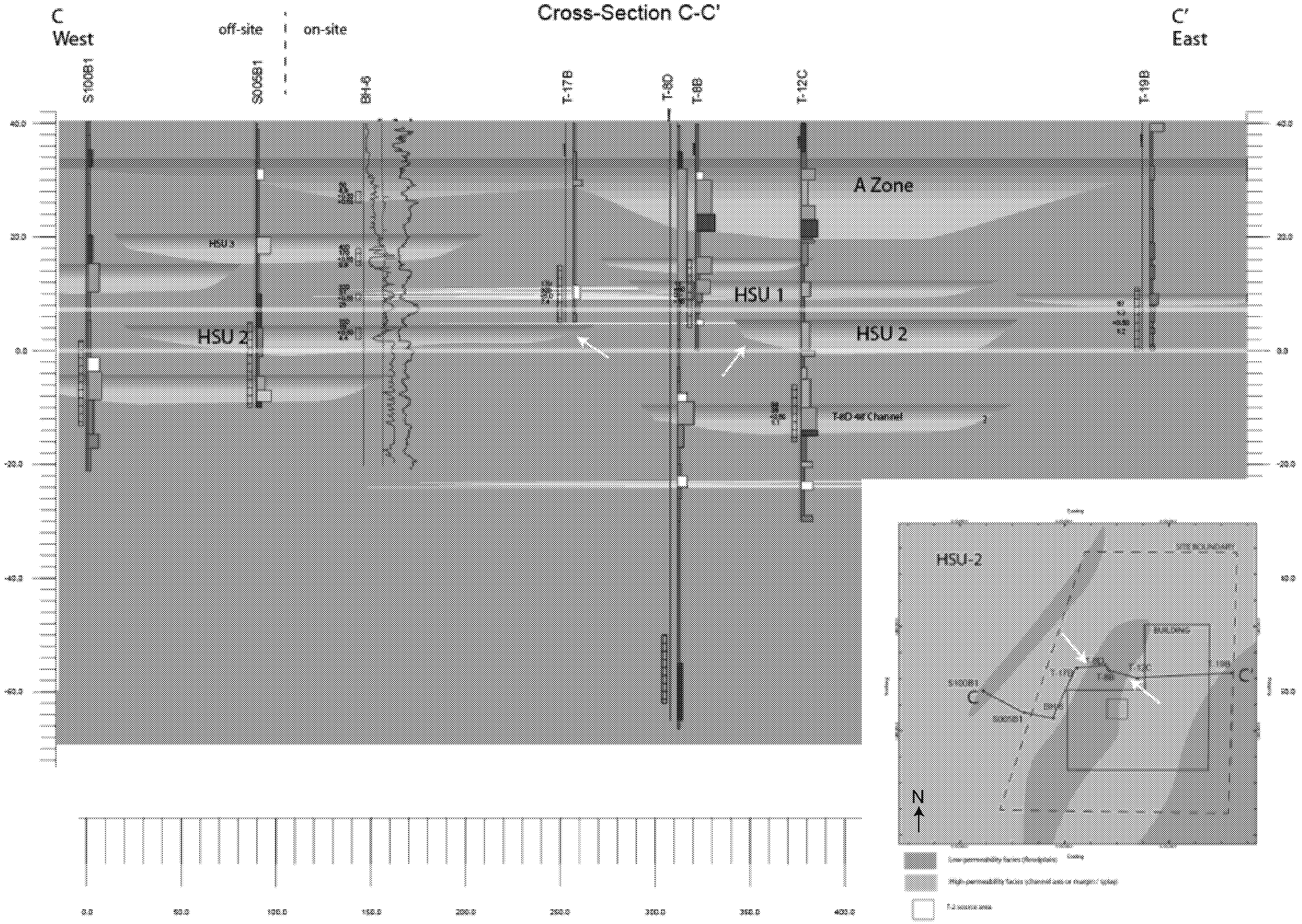
BURNS McDONNELL

Figure 26
Geologic Cross Section A
Former TRW Microwave Site
Sunnyvale, California



BURNS McDONNELL

Figure 27
Geologic Cross Section B
Former TRW Microwave Site
Sunnyvale, California



Cross Section C-C'. White arrows on cross section and map highlight margins of clay zone.

BURNS McDONNELL

Figure 28
Geologic Cross Section C
Former TRW Microwave Site
Sunnyvale, California